BI technologies
CORPORATION

THIRD EDITION

- Passive Networks
- Chip Resistors
- Power Resistors

- Trimmers
- Potentiometers
- Position Sensors

- Di
- Mc
- Hy
- Sc

MISSION STATEMENT

Our mission is to provide our customers with the highest level of product value, service, and quality in an environment of sustained and profitable growth for our employees and shareholders.

We will place the *Customer First* and will maintain the highest standards of ethical conduct in all our activities.

BI technologies CORPORATION

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BI Technologies, Corp. makes no representation that the use or interconnection of the circuits described herein will not infringe on existing or future patent rights, nor do the descriptions contained herein imply the granting of licenses to make, use or sell equipment constructed in accordance therewith.

NOTE: The information presented in this book is believed to be accurate and reliable. BI Technologies reserves the right to make changes to the products contained in this databook to improve performance, reliability, or manufacturability. However, no responsibility is assumed by BI Technologies for its use.

LIFE SUPPORT POLICY
BI Technologies' products are not authorized for use as critical components in the life support devices or systems without express written approval.

CORPORATE OVERVIEW

***BI Technologies** has been and innovator and leader in electronic components for 50 years. We have evolved and changed, in name and in form, while retaining our innovative spirit.*

Today our product line encompasses trimming potentiometers, precision potentiometers, position sensors, turns counting dials, resistor and resistor networks, integrated passive networks, transformers and inductors, hybrid and power hybrid microcircuits, and custom integration of these technologies.

We manufacture products on three continents and service customers globally from nine direct sales offices and over 200 representative and distributor offices. Our direct offices are located in:

- Fullerton, California
- Gagny, France
- Milan, Italy
- Singapore
- Glenrothes, Scotland
- Munich, Germany
- Tokyo, Japan
- Hong Kong

Astec PLC, is our parent company. Astec is a large publicly traded power conversion company with global sales and manufacturing locations.

Emerson Electric of St. Louis is Astec's largest shareholder. Emerson is an $8 billion publicly traded manufacturer with a wide range of products and affiliated companies.

These two world class organizations provide BI with tremendous resources for capital, technology exchange, and purchasing leverage – three resources essential to meet rapidly changing markets and cost pressures of our highly competitive environment.

***BI Technologies**, maintains its leadership through high quality, innovative solutions, a broad product offering and a sensitivity to the evolving needs of our customers.*

BI technologies
CORPORATION

THE HERITAGE OF INNOVATION

1940
First Helical potentiometer invented.

1944
"A" pot introduced – still in use today.

1951
High speed continuous winders developed.

1956
First "Cermet" processes developed for use in pots and trimmers (Cermet - a contraction of the words ceramic and metal.)

1958
Opening of our Scotland manufacturing facility.

1959
First turns counting dials introduced.

1962
First Cermet trimming potentiometer introduced.

1963
Introduction of Thick Film Microcircuits.

1964
Introduction of conductive plastic elements.

1964
Introduction of the RESNET® (resistor network)

1969
First hybrid element potentiometer introduced.

1970
Resistor networks introduced in 14 pin DIP packages.

1971
Introduction of the Teflon rotor, "Zero Backlash."

v

1974 *Introduction of Thin Film Precision networks.*

1977 *Opening of sales office in Tokyo, Japan.*

1980 *Opening of Mexicali, Mexico facility*

1984 ***BI becomes affiliated with Emerson Electric Co.***

1986 *Introduction of surface mount molded networks.*

1987 *Introduction of wound transformers and inductors for the power conversion market.*

1989 *Emerson Electric acquires minority interest in Astec (BSR) Plc.* ***BI becomes subsidiary of Astec (BSR) Plc.***

1991 *Implementation of customer driven manufacturing.*

1994 *Introduction of 4mm Square Sealed SMD Trimmers.*

1995 *Introduction of RC Chip Arrays*

It began with a single innovation. The helical potentiometer we created in 1940 was so ingenious, it is still in use today. This ability to anticipate and service customer needs has been the source of our reputation for 50 years. The concept shines bright today, and is a component of our *Customer First* philosophy.

In the 1950's, we responded to the need for inexpensive, heat resistant trimmers with a new material - cermet. Cermet began a revolution in trimming potentiometers and remains an industry standard today.

Every day, all around the world, our components are used in every conceivable application. From home computers to super computers, heart monitors and guitar monitors, instrumentation for the dashboard and the space shuttle – if it is electronic, it probably relies on BI components.

Dynamic, focused, and rich in heritage, **BI Technologies** continues its evolution. An evolution driven by customer need and the technology that serves those needs.

QUALITY

BI is committed to total customer satisfaction. We will provide our customers with defect-free products and service through a process of continuous quality improvement. We recognize that every employee, supplier and customer is an essential component of our quality improvement process. Only by supporting each other, can we provide quality products and service.

The above policy statement summarizes our commitment to producing and selling only top quality electronic components. In order to implement this policy and to track our progress, BI uses several tools and measurements.

CYCLE TIME REDUCTION

Reduced cycle times provide our customers with the exact parts that they want at the time that they want them. BI's factories operate with the shortest lead times in the industry, in some product lines less than 14 days. This is accomplished by a unique order processing system that we call "Daily Dispatch". Every day, our production schedule changes so that parts ordered by a customer are built first. This system allows for immediate changes and impressive flexibility.

INVENTORY REDUCTION

Minimum levels of work-in-process inventory also contribute to our manufacturing flexibility. Maintaining these low WIP inventories mandates that our processes operate to very high standards. Each part we make is designed for manufacturing ease; each assembly machine has a built-in process checks; and each operator is carefully trained before being assigned to any process. Controlled processes and excellent quality allow for low inventory.

ON-TIME DELIVERY

Our delivery commitments to our customers are continuously tracked by management and supervisors. If commitments are not made, a failure analysis is performed and corrective action is implemented to ensure that a similar situation does not reoccur.

OUTGOING QUALITY

Final audits are used to track the quality of parts as they might be received by customers. This data is used to determine our Average Outgoing Quality (AOQ). In 1994 our AOQ for some product lines is 0. Our other product lines are fast approaching this ultimate goal.

ISO 9000

Each of our primary manufacturing and design locations is certified to ISO 9000. Those sites which do not have a design function are certified to ISO 9002 and those which do perform a design function are certified to ISO 9001.

QUALITY IMPROVEMENT TOOLS

There are many tools which BI personnel use for problem solving and quality improvement. Among these the most important are statistical process control techniques, statistical design of experiments, and test equipment and gage reproducibility and repeatability studies.

DET NORSKE VERITAS

QUALITY SYSTEM CERTIFICATE

Certificate No. QSC - 3625 Rev.1

This is to certify that
the Quality System
of

BI TECHNOLOGIES CORPORATION

at
Fullerton, California USA

Has been found to conform to the Quality System Standard:

ISO 9001, 1994

This Certificate is valid for the following product or service ranges:

DESIGN AND MANUFACTURE OF TRIMMING POTENTIOMETERS, PRECISION POTENTIOMETERS, THIN FILM RESISTOR NETWORKS AND HYBRID MICROCIRCUITS

Place and date:
Rotterdam, May 24th, 1995

This Certificate is valid until:
January 20th, 1997

for the Accredited Unit:
DET NORSKE VERITAS INDUSTRY B.V.,
THE NETHERLANDS

R.J. Meijer
Management Representative
DNV Certification

Accredited by
the Dutch Council
for Certification
Reg.No.24

for Marc Bivona
Lead Auditor

Lack of fulfilment of conditions as set out in the Appendix may render this Certificate invalid.

Form No.: SFC-D-112E-07/93

DNVI 31A/93

DET NORSKE VERITAS INDUSTRY B.V. Haastrechtstraat 7, 3079 DC Rotterdam, The Netherlands, TEL.INT.:+31 10 479 86 00, FAX:+31 10 479 71 41

DET NORSKE VERITAS

QUALITY SYSTEM CERTIFICATE

Certificate No. QSC - 3457

This is to certify that
the Quality System
of

BICOMP S.A. DE C.V.

at
Mexicali, Mexico

Has been found to conform to the Quality System Standard:

ISO 9002, 1987

This Certificate is valid for the following product or service ranges:

MANUFACTURE OF POTENTIOMETERS AND VARIABLE RESISTORS

Place and date:
Rotterdam, October 4th 1993

This Certificate is valid until:
September 10th 1996

for the Accredited Unit:
DET NORSKE VERITAS INDUSTRY B.V.,
THE NETHERLANDS

Gunnar B. Castberg
Management Representative
DNV Certification

Accredited by
the Dutch Council
for Certification
Reg.No.24

Sidney Vianna
Lead Auditor

Lack of fulfilment of conditions as set out in the Appendix may render this Certificate invalid.

Form No.: SFC-D-112E-07/93 DNVI 31^A/93

DET NORSKE VERITAS INDUSTRY B.V. Haastrechtstraat 7, 3079 DC Rotterdam, The Netherlands, TEL.INT.:+31 10 479 86 00, FAX:+31 10 479 71 41

Certificate of Registration

BSI
REGISTERED FIRM

Certificate Number FM 26351

BI TECHNOLOGIES LIMITED
TELFORD ROAD
EASTFIELD INDUSTRIAL ESTATE
GLENROTHES, FIFE KY7 4NX

operate a quality management system which complies with the requirements of BS EN ISO 9001:1994

Signed on behalf of BSI

Accredited by the Dutch Council for Certification

Originally registered 22 November 1993 Amendments to 18 August 1995

This certificate remains the property of the British Standards Institution and shall be returned immediately upon request. This certificate does not expire. To check its validity telephone +44 (0)1908 227700

The British Standards Institution is incorporated by Royal Charter.

BSI Quality Assurance PO Box 375 Milton Keynes United Kingdom MK14 6LL

BSi QUALITY ASSURANCE

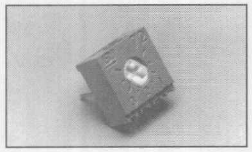
NATIONAL ACCREDITATION OF CERTIFICATION BODIES

Registration Number 003

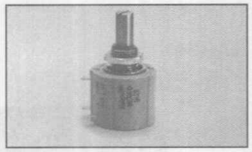
E329 Issue1

PRODUCT INDEX GUIDE

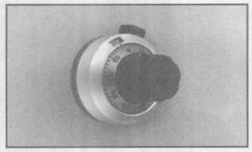
Trimming Potentiometers



Precision Potentiometers/ Position Sensors

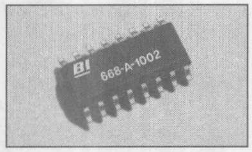


Turns Counting Dials



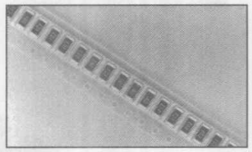
Passive Networks

- Resistor Networks
- Capacitor Networks
- Resistor Capacitor Networks
- Diode Networks

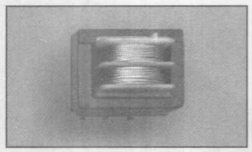


Discrete Components

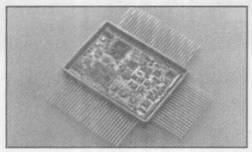
- Chip Resistors
- Power Resistors



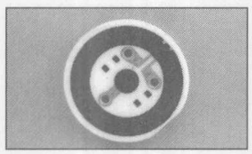
Magnetics Components



Hybrid Microcircuits



Screened Substrates



Trimming Potentiometers

MULTI-TURN CERMET TRIMMERS

MODEL NUMBER	ADJUSTMENT TURNS	HOUSING SIZE	ADJUSTMENT STYLE	MOUNTING STYLE	SEAL	STANDARD RESISTANCE RANGE (OHMS)	STANDARD RESISTANCE TOLERANCE	AVAILABLE* PACKAGING
RJ24	20	3/8" Sq.	Top, Side	Thru-Hole	Yes	10 to 1 Meg	±10%	TB
RJ26	15	1/4" Sq.	Top, Side	Thru-Hole	Yes	10 to 1 Meg	±10%	TB
44	9	4mm Sq.	Top, Side	Surface Mount	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	TR TB
64	15	1/4" Sq.	Top, Side	Thru-Hole	Yes	10 to 1 Meg	±10%	TR AP (64Y, 64Z Only)
84	15	1/4" Sq.	Top, Side	Surface Mount	Yes	10 to 1 Meg	±10%	TR
66	20	3/8" Sq.	Top, Side	Thru-Hole	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	TB TR AP (66W, 66X Only)
67	20	3/8" Sq.	Top, Side	Thru-Hole	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	TB TR (67W, 67X Only) AP (67W, 67X Only)
68	20	3/8" Sq.	Top, Side	Thru-Hole	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	TB TR (68W, 68X Only) AP (68W, 68X Only)
89	20	3/4" Rect.	Side	Thru-Hole	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	TB
78	22	1-1/4" Rect.	Side	Thru-Hole	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	

* AP = Ammo Pack
TR = Tape & Reel
TB = Tubes

SINGLE TURN CERMET TRIMMERS

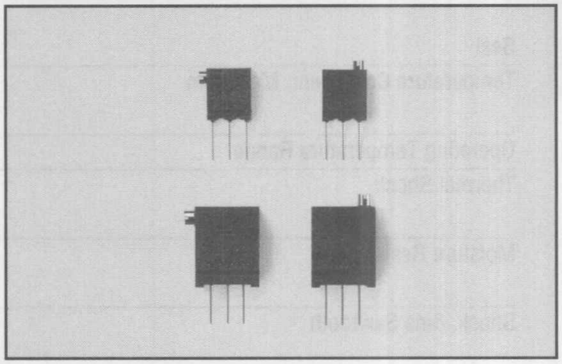
MODEL NUMBER	HOUSING SIZE	ADJUSTMENT STYLE	MOUNTING STYLE	SEAL	STANDARD RESISTANCE RANGE (OHMS)	STANDARD RESISTANCE TOLERANCE	AVAILABLE* PACKAGING
22	3mm Sq.	Top	Surface Mount	Yes	100 to 1 Meg	±20%	TR
21	4mm Sq.	Top	Surface Mount	Unsealed	500 to 500K	±30%	TR
23	4mm Sq.	Top	Surface Mount Thru-Hole	Yes	10 to 2 Meg	±20%	TR TB
24	4mm Dia.	Top, Side	Thru-Hole	Yes	10 to 1 Meg	±20%	TR (24U Only)
25	1/4" Sq.	Top, Side	Thru-Hole	Yes	10 to 2 Meg	±20%	TB (25U, 25V Only) TR AP (25U, 25V Only)
62	1/4" Dia.	Top	Thru-Hole	Yes	10 to 1 Meg	±10% (<100Ω=±20%)	TB (62P, 62M Only)
72	3/8" Sq.	Top, Side	Thru-Hole	Yes	10 to 2 Meg	±10% (<100Ω=±20%)	TB TR (72 RW Only) AP (72RW Only)
82	1/4" Dia.	Top, Side	Thru-Hole	Yes	10 to 1 Meg	±10% (<100Ω=±20%)	TB TR (82W Only) AP (82W Only)
83	1/4" Sq.	Top, Side	Surface Mount	Yes	10 to 1 Meg	±10% (<100Ω=±20%)	TB (83Y Only) TR (83P Only)
91	3/8" Dia.	Top, Side	Thru-Hole	Dust Cover	10 to 2 Meg	±20%	
93	1/2" Dia.	Top	Thru Hole	Yes	20 to 2 Meg	±10% (<100Ω=±20%)	

* AP = Ammo Pack
TR = Tape & Reel
TB = Tubes

RJ24, RJ26 SERIES

MIL-R-22097 Qualified Multi-Turn Cermet Trimming Potentiometers

NEW PRODUCT — Distributor Item



FEATURES/BENEFITS

- Teflon Rotor
- ISO 9000 Certified Factory

STYLES

RJ24	3/8" Square, Top or Side Adjustment
RJ26	1/4" Square, Top or Side Adjustment

ELECTRICAL

Standard Resistance Range, Ohms		10 to 1Meg
Standard Resistance Tolerance		±10%
Input Voltage, Maximum		200V dc or rms not to exceed power rating
Slider Current, Maximum		100mA or within rated power, whichever is less
Power Rating, Watts	RJ24:	0.5 at 85°C derating to 0 at 150°C
	RJ26:	0.25 at 85°C derating to 0 at 150°C
End Resistance, Maximum		2 Ohms or 2%
Actual Electrical Travel, Turns, Nominal	RJ24:	20
	RJ26:	11
Dielectric Strength	RJ24:	900V rms
	RJ26:	600V rms
Insulation Resistance, Minimum		1,000 Megohms
Resolution		Essentially infinite
Contact Resistance Variation, Maximum		3% or 3 Ohms, whichever is greater

Specifications subject to change without notice.

ENVIRONMENTAL (PER MIL-R-22097)

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	F = ±100ppm/°C C = 250ppm/°C
Operating Temperature Range	–65°C to +150°C
Thermal Shock	5 cycles, –65°C to +150°C (1% ΔR_T, 1% ΔVR) MIL-STD-202, Method 107, Test Condition B
Moisture Resistance	Ten 24 hour cycles (1% ΔR_T, IR 100 Megohms Min.) Method 106, 96 hours
Shock, 6ms Sawtooth	100G's (1% ΔR_T, 1% ΔVR) MIL-STD-202, Method 213, Test Condition I
Vibration	20G's, 10 to 2,000 Hz (1% ΔR_T, 1% ΔVR) MIL-STD-202, Method 204, Test Condition D
High Temperature Exposure	250 hours at 150°C (2% ΔR_T, 2% ΔVR)
Rotational Life	200 cycles (2% ΔR_T)
Load Life at 0.5 Watts	1,000 hours at 85°C (2% ΔR_T) MIL-STD-202, Method 108, Test Condition D
Resistance to Solder Heat	350°C for 3 sec. (1% ΔR_T)

Fluorinert® is a registered trademark of 3M Company.

MECHANICAL

Mechanical Stops	Clutch action, both ends
Torque, Operating, Maximum	RJ24: 5 oz.-in. (0.035 N-m) RJ26: 3 oz.-in. (0.021 N-m)
Weight, Maximum	RJ24: .04 oz. (1.3 grams) RJ26: .014 oz. (.6 grams)

ORDERING INFORMATION

Model RJ24:

RJ24 F W 103 TB

Series

Tempco:
F = 100ppm/°C
C = 250ppm/°C

Packaging Option:
TB = Tubes

Resistance Code:
Refer to Ohms/Code Chart, Pg. 4

Pin Style:
P, W or X

Model RJ26:

RJ26 F W 103

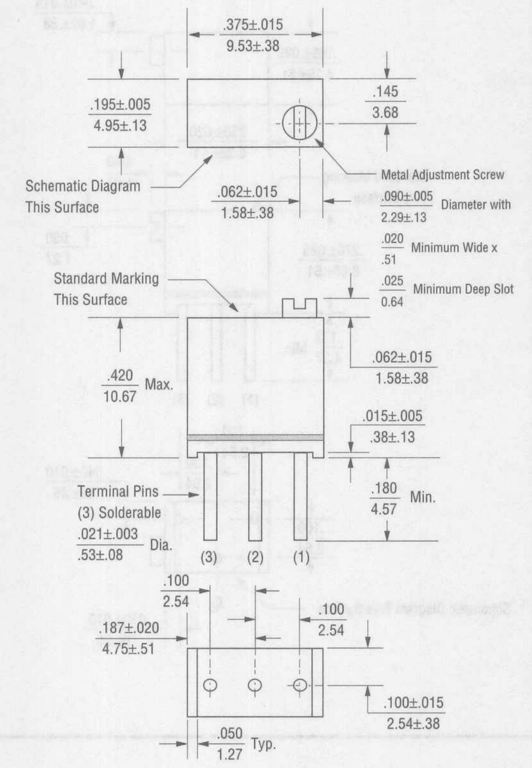
Series

Tempco:
F = 100ppm/°C
C = 250ppm/°C

Resistance Code:
Refer to Ohms/Code Chart, Pg. 4

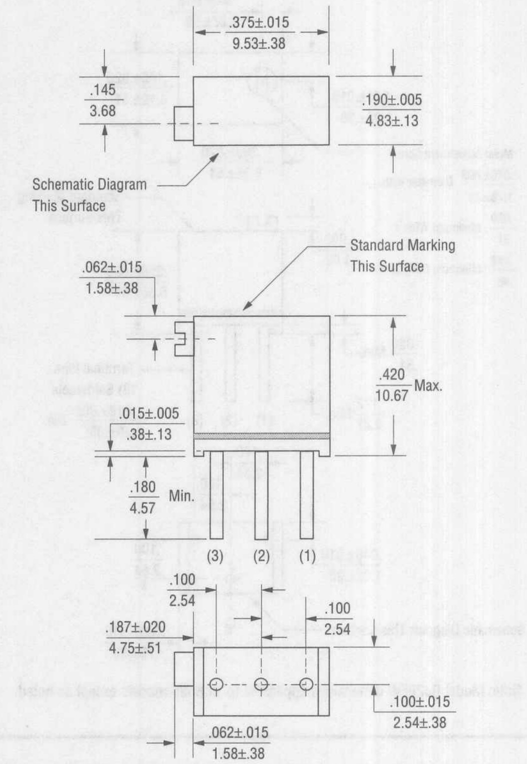
Pin Style:
P, W or X

TOP ADJUSTMENT - RJ24FW

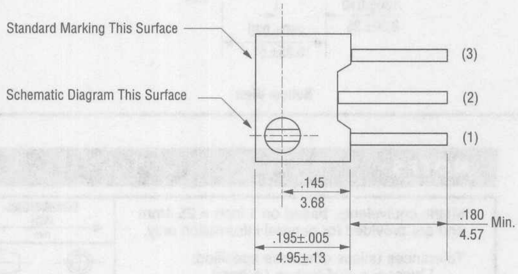


Note: Model RJ24FW dimensions applicable to all RJ24 models except as noted.

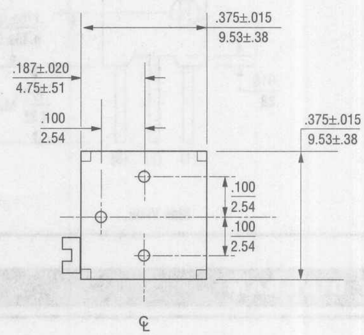
SIDE ADJUSTMENT - RJ24FX



SIDE ADJUSTMENT - RJ24FP

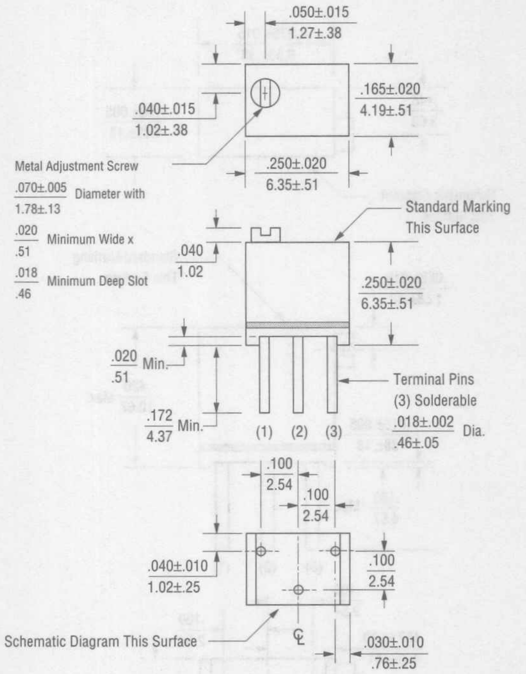


Side View



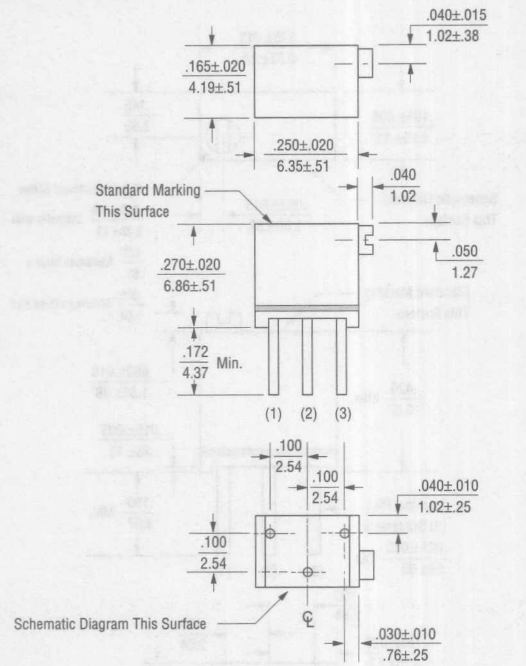
Bottom View

TOP ADJUSTMENT - RJ26FW

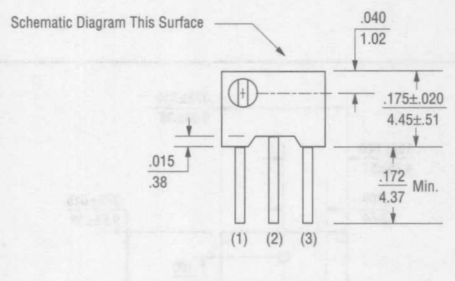


Note: Model RJ26FW dimensions applicable to all RJ26 models except as noted.

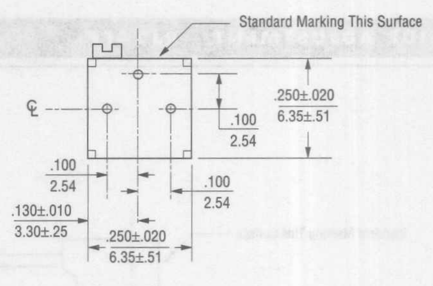
SIDE ADJUSTMENT - RJ26FX



SIDE ADJUSTMENT - RJ26FP

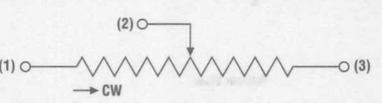


Side View



Bottom View

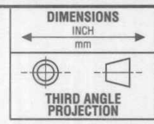
CIRCUT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .005 inches (.13mm)
Angular = ± 2 degrees



STANDARD RESISTANCE VALUES

Ohms	10	20	50	100	200	500	1,000	2,000	5,000	10,000	20,000	25,000	50,000	100,000	250,000	500,000	1,000,000
Code	100	200	500	101	201	501	102	202	502	103	203	253	503	104	254	504	105

PACKAGING FOR MODEL RJ24

Standard: Boxes

Capacity, Units = 100

Option: Tubes

All Units oriented with #1 pin to same side

	Pin Style		P	W	X
Magazine:	Width	=	0.57"	0.28"	0.28"
	Height	=	0.66"	0.93"	0.93"
	Length	=	20.9"	20.6"	24.4
	Capacity, Units	=	100	100	100

PACKAGING FOR MODEL RJ26

Standard: Tubes

All Units oriented with #1 pin to same side

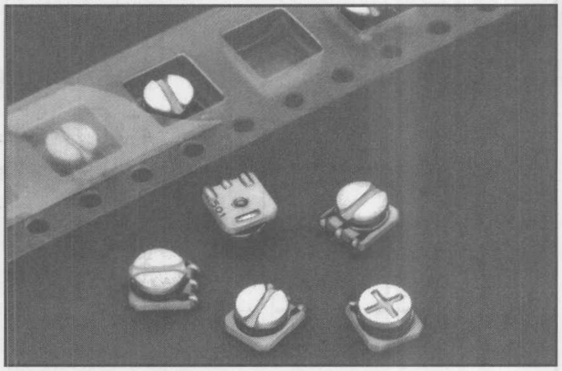
	Pin Style		P,W	X
Magazine:	Width	=	0.38"	0.38"
	Height	=	0.62"	0.62"
	Length	=	14.5"	16.9"
	Capacity, Units	=	50	50

MODEL 21

4mm Surface Mount Chip Cermet Trimming Potentiometers

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	500 to 500K
Standard Resistance Tolerance	±30%
Input Voltage, Maximum	50 Vdc or rms not to exceed power rating
Power Rating, Watts	0.1 at 70°C derating to 0 at 100°C
End Resistance, Maximum	1% or 5 Ohms, whichever is greater
Actual Electrical Travel, Nominal	250°
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	3%

ENVIRONMENTAL

Temperature Coefficient, Maximum	±250ppm/°C
Operating Temperature Range	−40°C to +100°C
Thermal Shock	5 cycles, −40°C to +100°C (5% ΔRT)
Rotational Life	25 cycles (10% ΔRT)
Load Life at 0.1 Watts	1,000 hours at 70°C (15% ΔRT)
Resistance to Solder Heat	260°C for 5 sec. (2% ΔRT)
Humidity	40°C, 90 to 95% RH, 500 hours (5% ΔRT)
Temperature Exposure, Maximum	248°C, 3 sec.

MECHANICAL

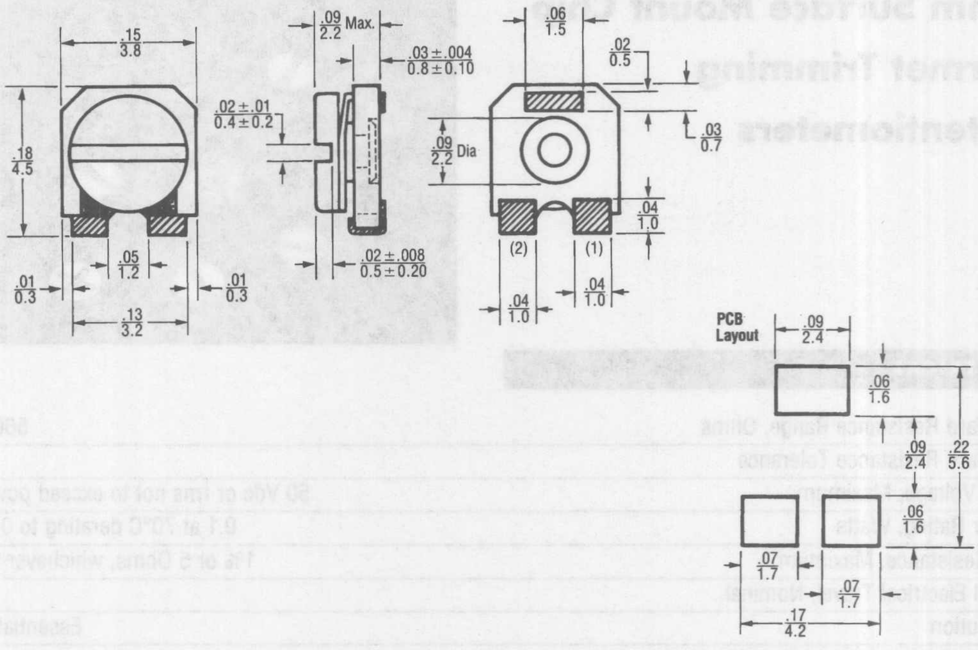
Torque, Maximum	4 oz.-in. (300 gr-cm)
Weight, Nominal	.004 oz. (0.11 grams)

Specifications subject to change without notice.

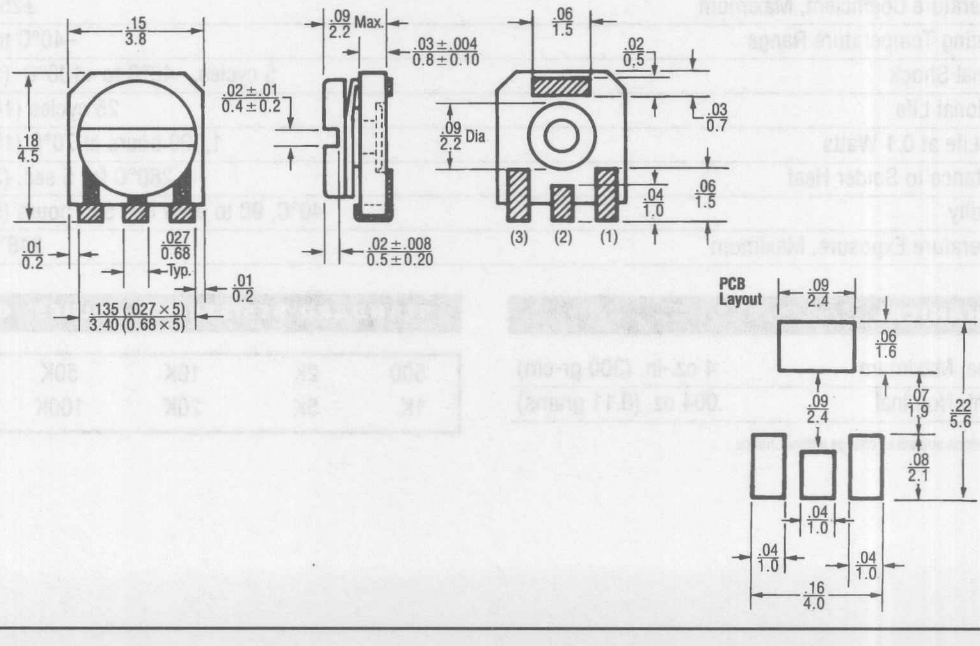
STANDARD RESISTANCE VALUES, OHMS

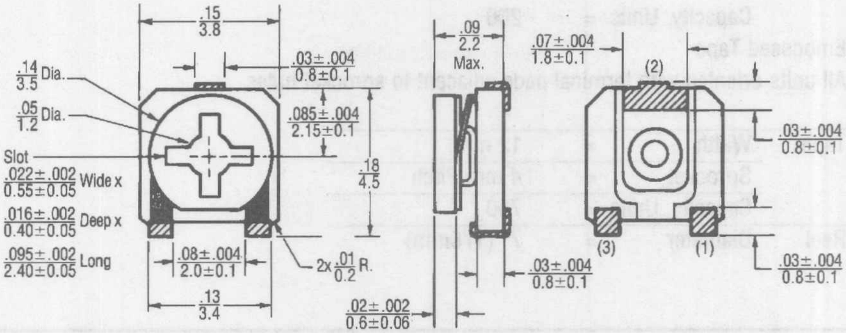
500	2K	10K	50K	200K
1K	5K	20K	100K	500K

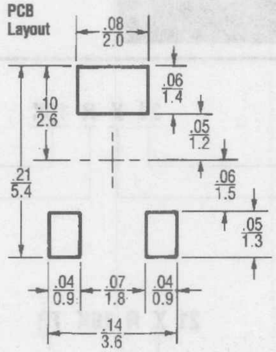
MODEL 21W



MODEL 21X




.15 / 3.8
.14 / 3.5 Dia.
.05 / 1.2 Dia.
Slot
.022±.002 / 0.55±0.05 Wide x
.016±.002 / 0.40±0.05 Deep x
.095±.002 / 2.40±0.05 Long
.03±.004 / 0.8±0.1
.085±.004 / 2.15±0.1
.18 / 4.5
.08±.004 / 2.0±0.1
2x .01 / 0.2 R.
.13 / 3.4
.09 / 2.2 Max.
.02±.002 / 0.6±0.06
.07±.004 / 1.8±0.1
(2)
(3)
(1)
.03±.004 / 0.8±0.1
.03±.004 / 0.8±0.1
.03±.004 / 0.8±0.1


PCB
Layout
.08 / 2.0
.06 / 1.4
.10 / 2.6
.05 / 1.2
.21 / 5.4
.06 / 1.5
.05 / 1.3
.04 / 0.9
.07 / 1.8
.04 / 0.9
.14 / 3.6

PACKAGING

Standard: Plastic Bags

Capacity, Units = 200

Option: Embossed Tape

All units oriented with terminal pads adjacent to sprocket holes

Tape	Width	=	12 mm
	Sprocket	=	4 mm Pitch
	Capacity, Units	=	750
Reel	Diameter	=	7" (178mm)

ORDERING INFORMATION

Standard:

21 X R 10K

Model Series — 21
Style — X
Resistance Prefix — R
Resistance Value — 10K

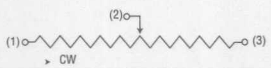
Option:

21 X R 10K TR

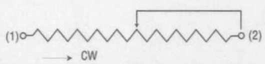
Style — X
Packaging Option — TR
TR = Tape & Reel

CIRCUIT DIAGRAM

Models 21X and 21Z



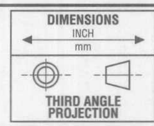
Model 21W



NOTES

English equivalents are based on 1 inch = 25.4mm and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± 0.3 mm (.01 in.)

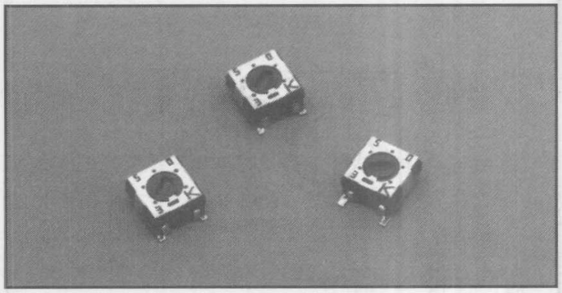


MODEL 22

3mm Single Turn Sealed Surface Mount Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	100 to 1Meg
Standard Resistance Tolerance	±20%
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Power Rating, Watts	0.125 at 70°C derating to 0 at 125°C
End Resistance, Maximum	1% or 3 Ohms, whichever is greater
Actual Electrical Travel, Nominal	220°
Dielectric Strength	500Vrms
Insulation Resistance, Minimum	100 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	3% or 3 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert®
Temperature Coefficient, Maximum	±100ppm/°C (<200 ohms = ±250ppm/°C)
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (2% ΔR, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (3% ΔR)
Shock, 6ms Sawtooth	100G's (1% ΔR, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔR, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔR, 2% ΔVR)
Rotational Life	100 cycles (5% ΔR)
Load Life at 0.25 Watts	1,000 hours at 70°C (3% ΔR, 2% ΔVR)
Resistance to Solder Heat	260°C for 5 sec. (1% ΔRT, 2% ΔVR)

MECHANICAL

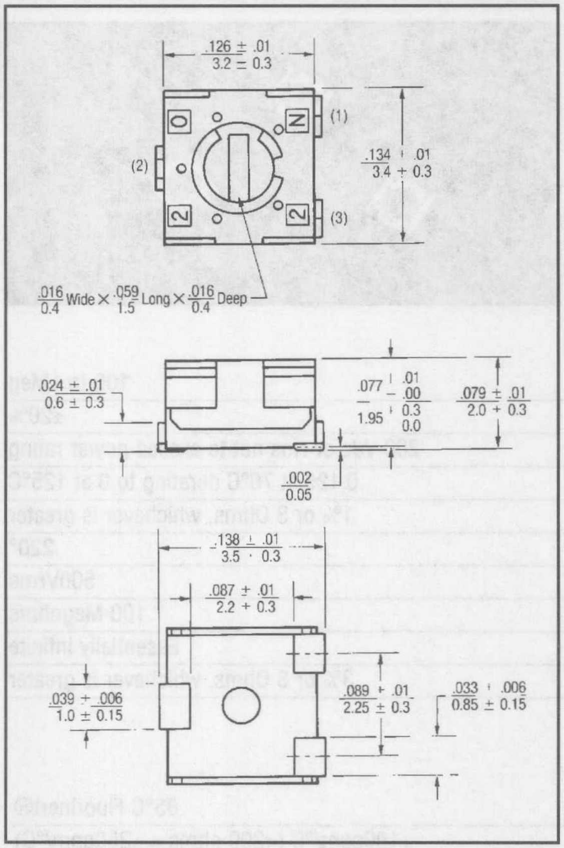
Mechanical Stops	Solid
Stop Strength, Minimum	1.3 oz.-in. (100 gr-cm)
Torque, Maximum	.65 oz.-in. (50 gr-cm)
Weight, Nominal	.002 oz. (0.068 grams)

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

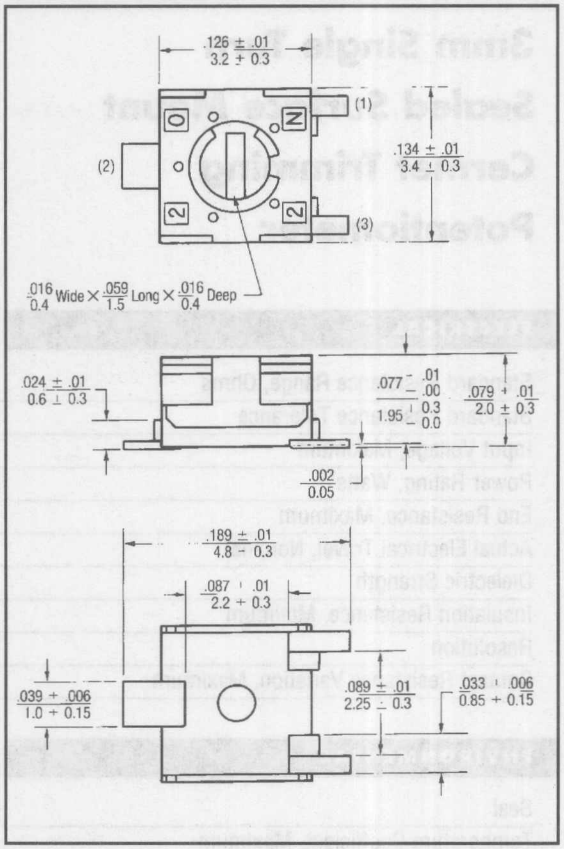
STANDARD RESISTANCE VALUES, OHMS

100	1K	10K	100K	1Meg
200	2K	20K	200K	
500	5K	50K	500K	

MODEL 22A - J HOOK

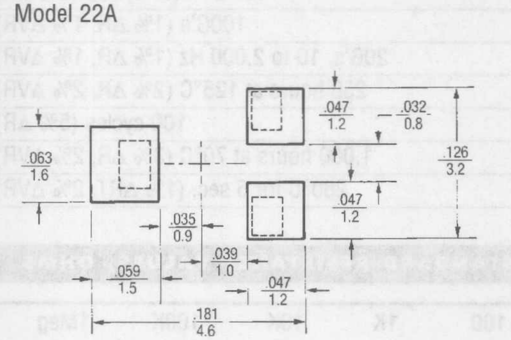


MODEL 22B - GULL WING

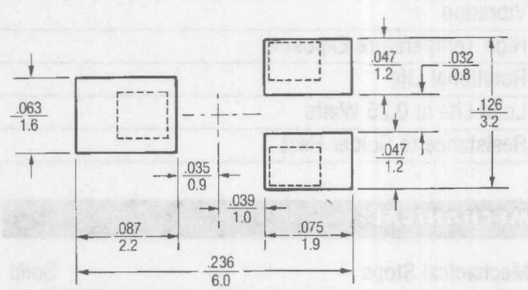


RECOMMENDED PCB LAYOUT

Model 22A



Model 22B



PACKAGING

Standard: Plastic Bags
Capacity = 100 Units

Option: Embossed Tape
All units oriented with #2 (slider) terminal pads adjacent to sprocket holes

Tape	Width	=	12 mm
	Sprocket	=	4 mm Pitch
	Capacity	=	1,000 Units
Reel	Diameter	=	7" (178mm)

ORDERING INFORMATION

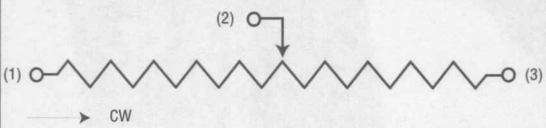
Standard: **22 A R 10K**

- 22 — Model Series
- A — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value

Option: **22 A R 10K TR**

- A — Pin Style
- TR — Packaging Option
  TR = Tape & Reel

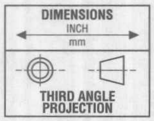
CIRCUIT DIAGRAM



NOTES

English equivalents are based on 1 inch = 25.4mm and are provided for general information only.

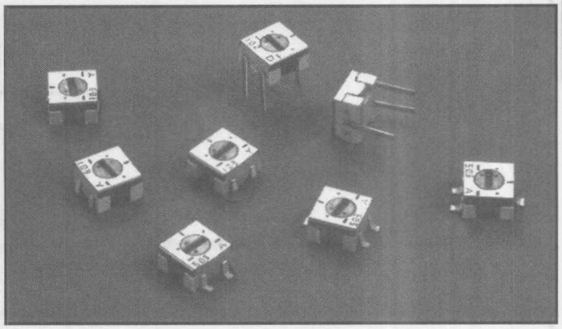
Tolerances unless otherwise specified:
Linear = ± 0.3 mm (.01 in.)



MODEL 23A, B, C, S

Distributor Item

4mm Square
Sealed Single Turn
Surface Mount
Cermet Trimming
Potentiometer



ELECTRICAL

Standard Resistance Range, Ohms	100 to 2Meg
Standard Resistance Tolerance	±20%
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Power Rating, Watts	0.25 at 70°C derating to 0 at 125°C
End Resistance, Maximum	1% or 3 Ohms, whichever is greater
Actual Electrical Travel, Nominal	200°
Dielectric Strength	500 Vrms
Insulation Resistance, Minimum	100 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	2% or 3 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C <200 Ohms, >1Meg = ±250ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (2% ΔRT, 2% ΔVR)
Moisture Resistance	Ten 24 hour cycles (3% ΔRT)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	100 cycles (5% ΔRT)
Load Life at 0.25 Watts	1,000 hours at 70°C (3% ΔRT, 1% ΔVR)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Solid
Stop Strength, Minimum	4 oz.-in. (300 gr-cm)
Torque, Maximum	2 oz.-in. (150 gr-cm)
Weight, Nominal	.005 oz. (0.14 grams)

STANDARD RESISTANCE VALUES, OHMS

100	1K	10K	100K	1Meg
200	2K	20K	200K	2Meg
500	5K	50K	500K	

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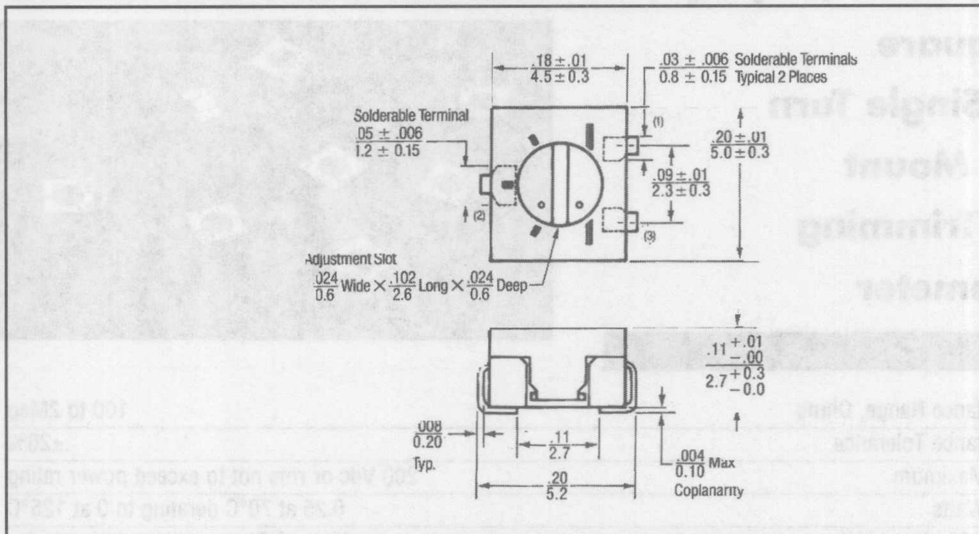
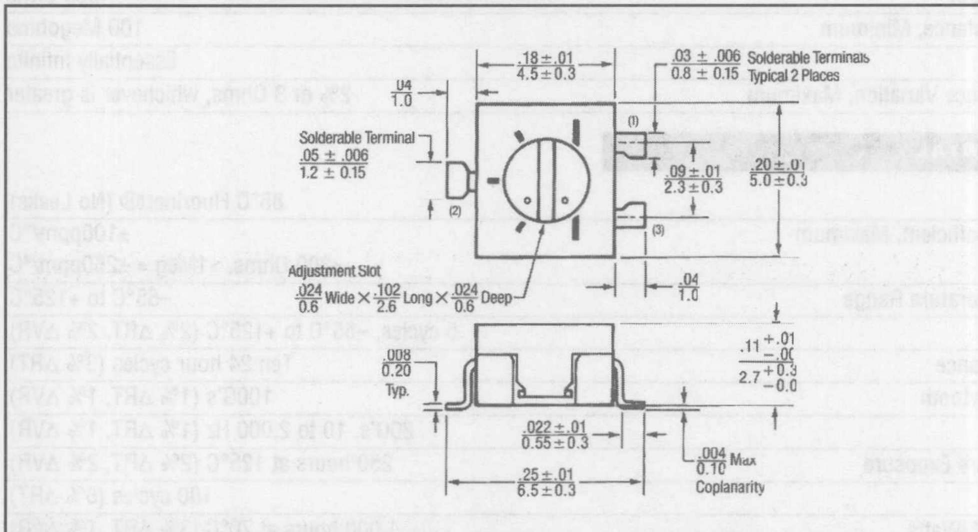
Specifications subject to change without notice.

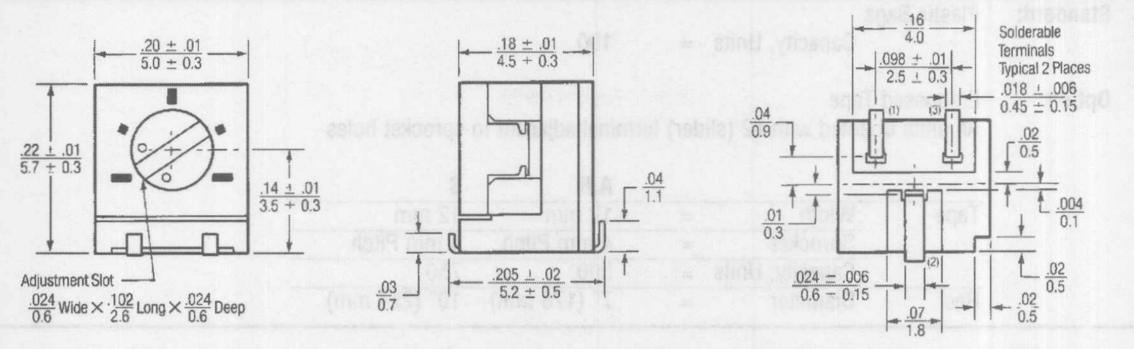
MODEL 23A - J HOOK



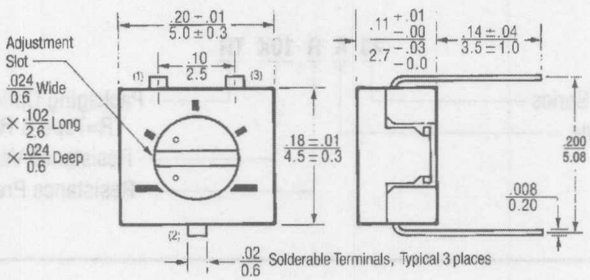
MODEL 23B - GULL WING



MODEL 23S-SIDE ADJUSTMENT

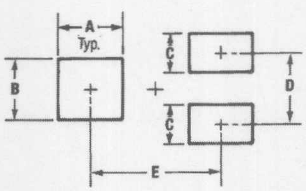


MODEL 23C-THROUGH HOLE



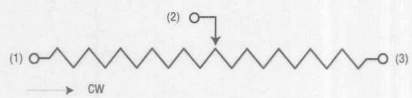
NOTE: Bottom adjustment version available – consult factory.

PCB LAYOUT



	23A	23S	23B
A	.08/2.0	.069/1.75	.05/1.3
B	.08/2.0	.06/1.6	.08/2.0
C	.05/1.3	.047/1.2	.05/1.3
D	.09/2.3	.09/2.3	.09/2.3
E	.16/4.1	.16/4.1	.22/5.5

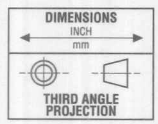
CIRCUIT DIAGRAM



NOTES

English equivalents are based on 1 inch = 25.4mm and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± 0.3 mm (.01 inches)



PACKAGING

Standard: Plastic Bags

Capacity, Units = 100

Option: Embossed Tape

All units oriented with #2 (slider) terminal adjacent to sprocket holes

			A,B	S
Tape	Width	=	12 mm	12 mm
	Sprocket	=	4 mm Pitch	4 mm Pitch
	Capacity, Units	=	500	750
Reel	Diameter	=	7" (178 mm)	10" (254 mm)

ORDERING INFORMATION

Standard:

23 A R 10K TR

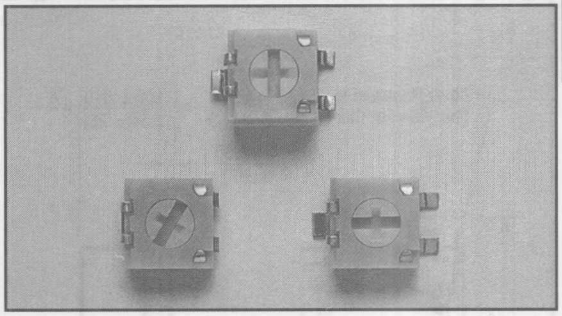
- 23 — Model Series
- A — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value
- TR — Packaging Option: TR=Tape & Reel

MODEL 23G, GL & J

Distributor Item

1

4mm Square Sealed Single Turn Surface Mount Cermet Trimming Potentiometer



FEATURES AND BENEFITS

- Space saving SMD design for the most compact board designs
- Sealed to withstand aggressive water wash
- BI quality and reliability
- Available in J-hook or gull wing termination
- T-Cross slot
- Ultra low profile

ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±20%
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Power Rating, Watts	0.25 at 70°C derating to 0 at 125°C
End Resistance, Maximum	1% or 3 Ohms, whichever is greater
Actual Electrical Travel, Nominal	210°
Dielectric Strength	500 Vrms
Insulation Resistance, Minimum	100 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	2% or 3 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
	<100 Ohms, >1Meg = ±150ppm/°C
Operating Temperature Range	−55°C to +125°C
Thermal Shock	5 cycles, −55°C to +125°C (2% ΔRT, 1% ΔVR)
Moisture Resistance	Ten cycles, 240 hours (3% ΔRT)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	100 cycles (3%)
Load Life at 0.25 Watts	1,000 hours at 70°C (3% ΔRT, 1% CVR)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

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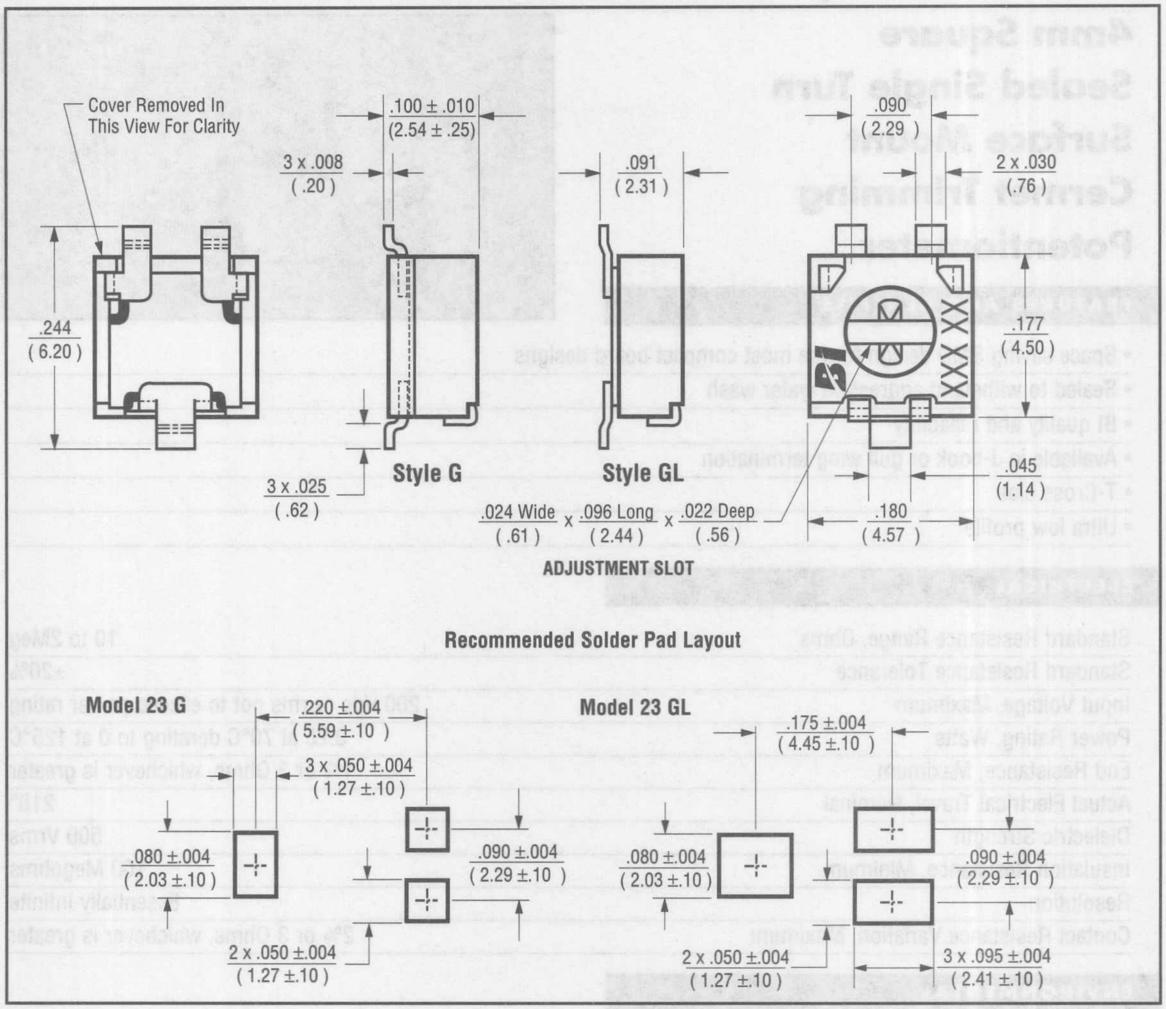
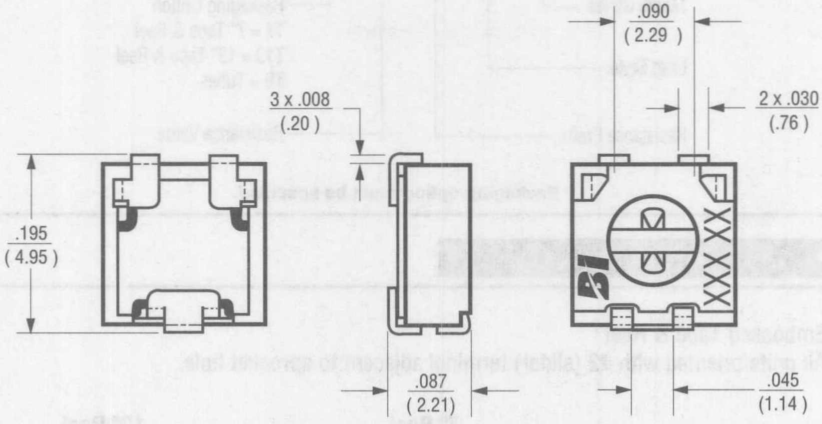
Specifications subject to change without notice.



MECHANICAL

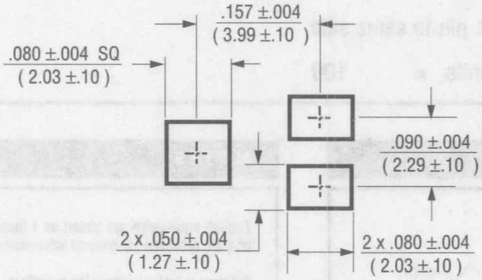
Mechanical Stops	Solid
Stop Strength, Minimum	4 oz.-in. (300 gr-cm)
Torque, Maximum	2 oz.-in. (150 gr-cm)
Weight, Nominal	.005 oz. (0.07 grams)

MODEL 23J



Recommended Solder Pad Layout

Model 23 J



STANDARD RESISTANCE VALUES, OHMS

100	1K	10K	100K	1Meg
200	2K	20K	200K	2Meg
500	5K	50K	500K	

ORDERING INFORMATION

Standard: 23 G R 10K XX *

- Model Series — 23
- Lead Style — G
- Resistance Prefix — R
- Resistance Value — 10K
- Packaging Option — XX
  - T7 = 7" Tape & Reel
  - T13 = 13" Tape & Reel
  - TB = Tubes

*** Packaging option must be specified.**

PACKAGING

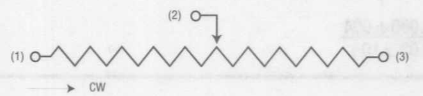
Option: Embossed Tape & Reel
All units oriented with #2 (slider) terminal adjacent to sprocket hole.

			7" Reel	**13" Reel**
Tape	Width	=	.472" (12mm)	.472" (12mm)
	Sprocket	=	.157" (4mm) pitch	.157" (4mm) pitch
	Capacity, Units	=	500	3,000
Reel	Diameter	=	7" (178 mm)	13" (330.2 mm)

Option: Anti-Static Tubes
All units oriented with #1 pin to same side

Magazine Capacity, Units = 100

CIRCUIT DIAGRAM



NOTES

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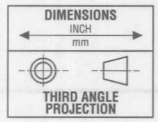
Tolerances unless otherwise specified:
Linear = ± .010 inches (.25 mm.)

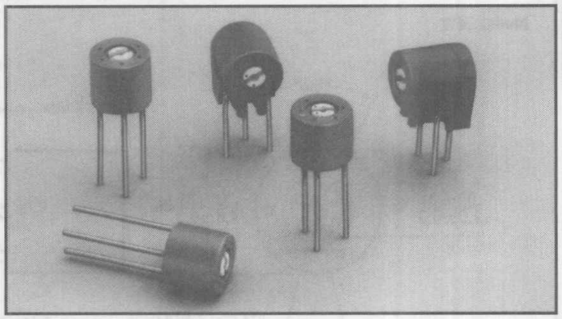


MODEL 24

4mm Diameter Single Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 1Meg
Standard Resistance Tolerance	±20% (±10% available)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Power Rating, Watts	0.5 at 70°C derating to 0 at 125°C
End Resistance, Maximum	1% or 3 Ohms, whichever is greater
Actual Electrical Travel, Nominal	190°
Dielectric Strength	500Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	2% or 3 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert®
Temperature Coefficient, Maximum	±100ppm/°C (<200 ohms = ±250ppm/°C)
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (2% ΔRT, 2% ΔVR)
Moisture Resistance	Ten 24 hour cycles (3% ΔRT)
Shock, 6ms Sawtooth	100G's (2% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 1% ΔVR)
Rotational Life	200 cycles (5% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (3% ΔRT)
Resistance to Solder Heat	350°C for 3 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Solid
Stop Strength, Minimum	3 oz.-in. (200 gr-cm)
Torque, Maximum	2 oz.-in. (150 gr-cm)
Weight, Nominal	.01 oz.(0.2 grams)

STANDARD RESISTANCE VALUES, OHMS

100	1K	10K	100K	1Meg
200	2K	20K	200K	
500	5K	50K	500K	

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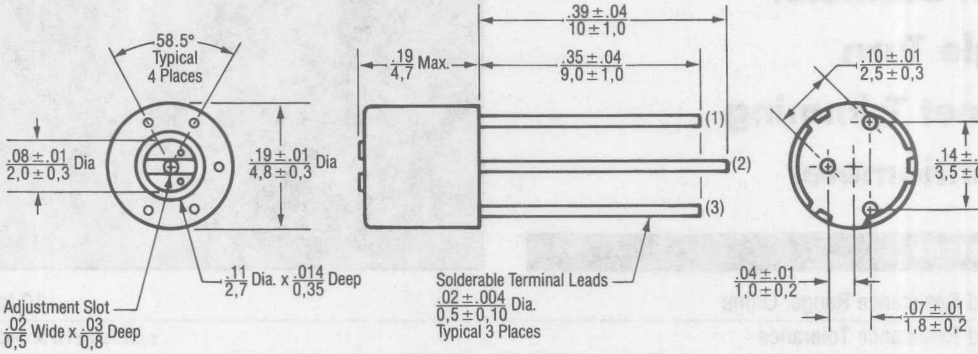
Specifications subject to change without notice.

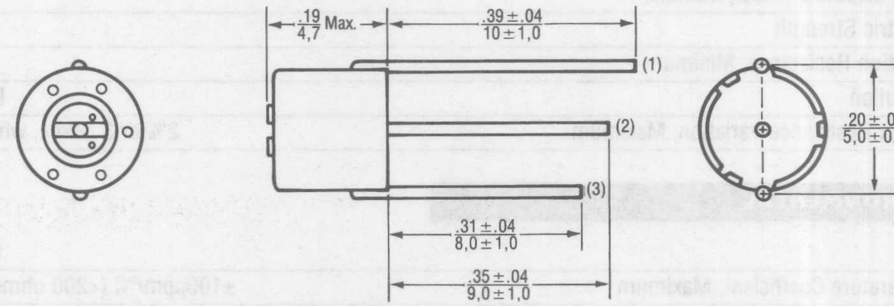
TOP ADJUSTMENT

Model 24W



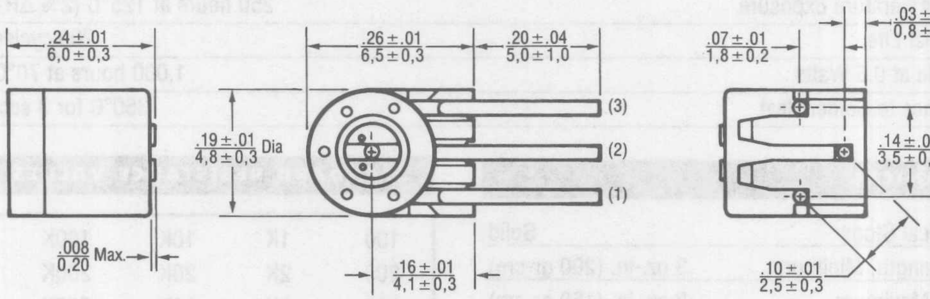
Note: Model 24W dimensions applicable to all other models except as noted

Model 24U



SIDE ADJUSTMENT

Model 24S



PACKAGING

Standard: Plastic Bags

	Capacity, Units	=	100

Option: Tape & Reel (24U only)

All units oriented with #3 pin toward direction of feed

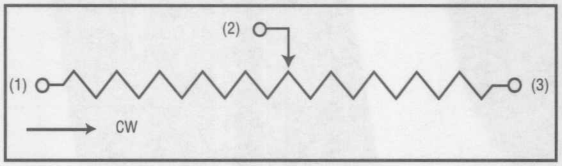
	Seat Plane to Centerline of Sprocket Hole	=	.71" (18 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (363 mm)

ORDERING INFORMATION

Standard: **24 W R 10K TR**

- 24 — Model Series
- W — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value
- TR — Packaging Option: TR=Tape & Reel

CIRCUIT DIAGRAM



NOTES

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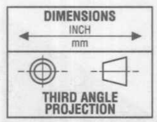
Tolerances unless otherwise specified:
Linear = ± 0.3 mm (.01 in.)

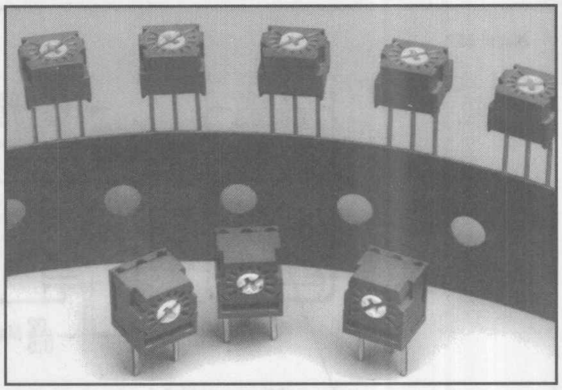


MODEL 25

1/4" Square Single Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±20% (±10% available)
Input Voltage, Maximum	250 Vdc or rms not to exceed power rating
Power Rating, Watts	0.5 at 70°C derating to 0 at 125°C
End Resistance, Maximum	1% or 3 Ohms, whichever is greater
Actual Electrical Travel, Nominal	210°
Dielectric Strength	500Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C (<200 ohms = ±250ppm/°C)
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (2% ΔRT, 2% ΔVR)
Moisture Resistance	Ten 24 hour cycles (3% ΔRT)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's,10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	100 cycles (5% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (3% ΔRT, 3% ΔVR)

MECHANICAL

Mechanical Stops	Solid
Stop Strength, Minimum	6 oz.-in. (500 gr-cm)
Torque, Maximum	3 oz.-in. (200 gr-cm)
Weight, Nominal	.01 oz. (0.4 grams)

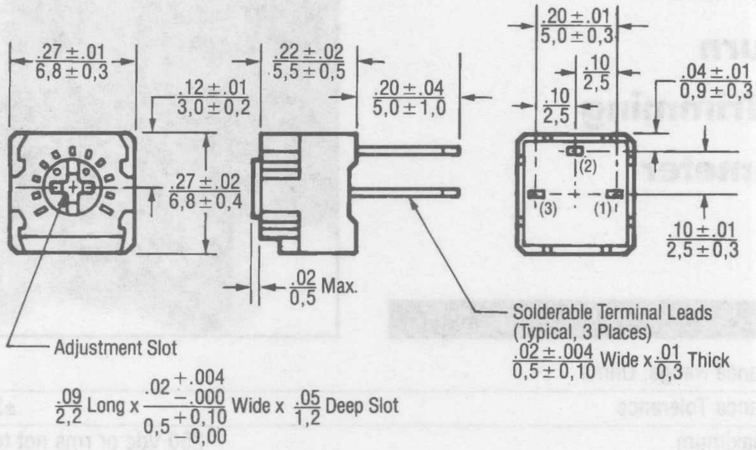
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

10	100	1K	10K	100K	1Meg
20	200	2K	20K	200K	2Meg
50	500	5K	50K	500K	

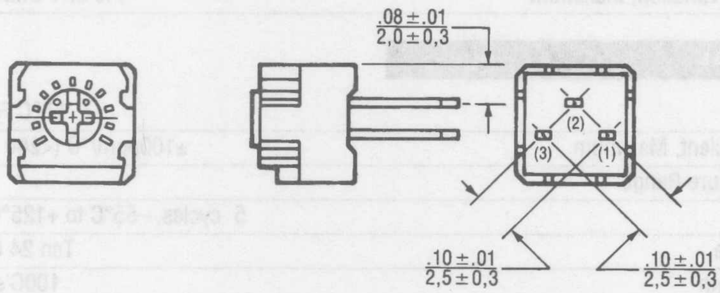
TOP ADJUSTMENT

Model 25P

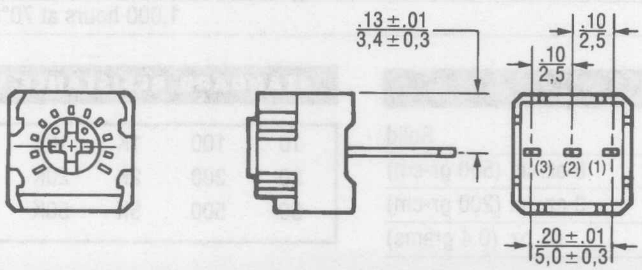


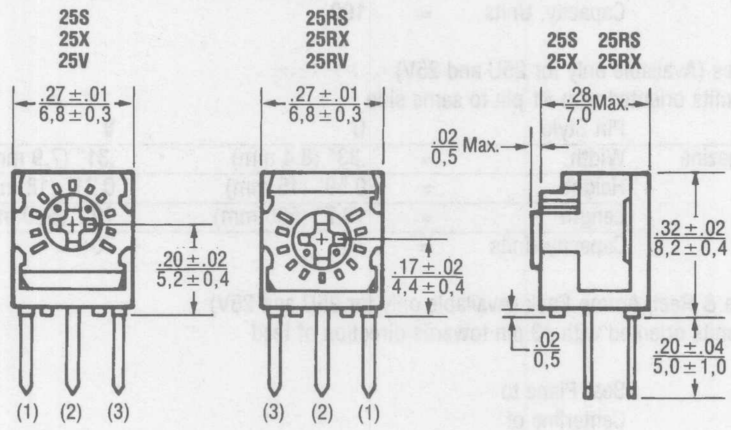
Note: Model 25P dimensions applicable to all models except as noted

Model 25W

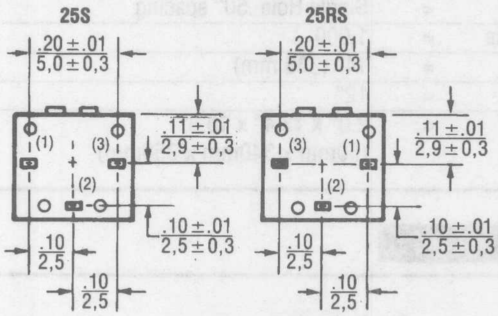


Model 25U



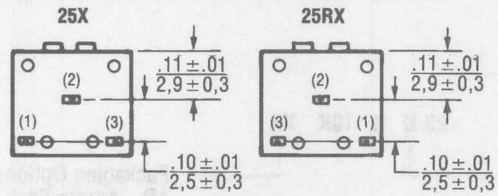


Model 25S and 25RS

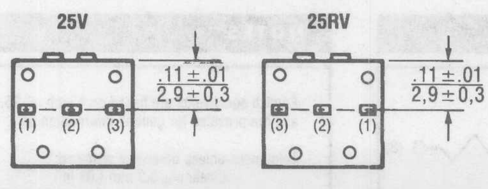


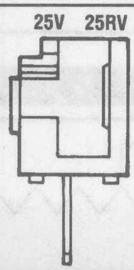
Note:
Models 25S and 25RS dimensions applicable to all side adjustment models except as noted.

Model 25X and 25RX



Model 25V and 25RV





PACKAGING

Standard: Plastic Bags

	Capacity, Units	=	100	

Option: Tubes (Available only for 25U and 25V)
All units oriented with #1 pin to same side

	Pin Style		U	V
Magazine	Width	=	.33" (8.4 mm)	.31" (7.9 mm)
	Height	=	0.59" (15 mm)	0.71" (18 mm)
	Length	=	19.7" (500 mm)	19.7 (500 mm)
	Capacity Units	=	70	70

Option: Tape & Reel, Ammo Pack (Available only for 25U and 25V)
All units oriented with #3 pin towards direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (363 mm)
Ammo	Tape Fold	=	12"
	Box	=	2.0" x 13.4" x 13.8" (50mm x 340mm x 350mm)

ORDERING INFORMATION

Standard:

25 P R 10K

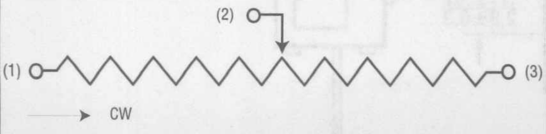
Model Series — 25
Pin Style — P
Resistance Prefix — R
Resistance Value — 10K

Option:

25 U R 10K XX

Pin Style — U
Packaging Options — XX
AP = Ammo Pack
TR = Tape & Reel
TB = Tubes

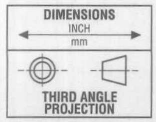
CIRCUIT DIAGRAM



NOTES

English equivalents are based on 1 inch = 25.4mm and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± 0.3 mm (.01 in.)

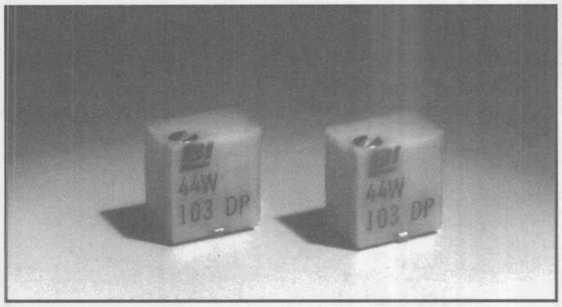


MODEL 44

4mm Square Multi-Turn Surface Mount Cermet Trimming Potentiometer

NEW PRODUCT — Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	300 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.25 at 85°C derating to 0 at 150°C
End Resistance, Maximum	1% or 2 Ohms, whichever is greater
Actual Electrical Travel, Turns, Nominal	9
Dielectric Strength	600Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 3 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Operating Temperature Range	–65°C to +150°C
Thermal Shock	5 cycles, –65°C to +150°C (2% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (2% ΔRT, IR 10 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
Rotational Life	200 cycles (3% ΔRT, 1% CRV)
Load Life at 0.25 Watts	1,000 hours at 85°C (2% ΔRT, 1% CRV)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)
Temperature Exposure, Maximum	215°C for 3 min. (1% ΔRT)
Solderability	Per MIL-STD-202, Method 208

MECHANICAL

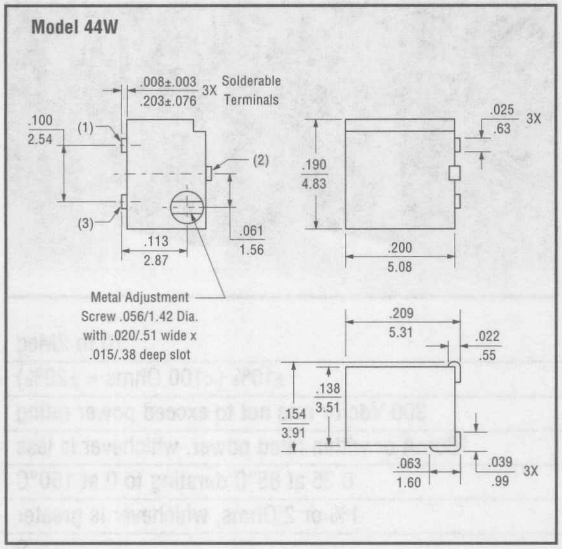
Mechanical Stops	Clutch action, both ends
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.01 g

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

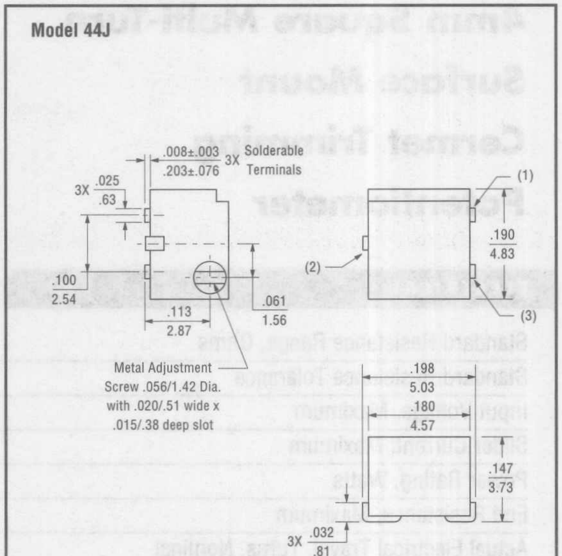
STANDARD RESISTANCE VALUES, OHMS

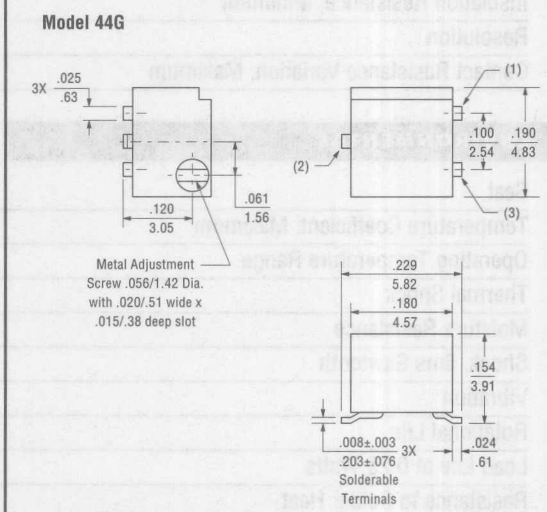
10	100	1K	10K	50K	250K
20	200	2K	20K	100K	500K
50	500	5K	25K	200K	1Meg
					2Meg

TOP ADJUSTMENT

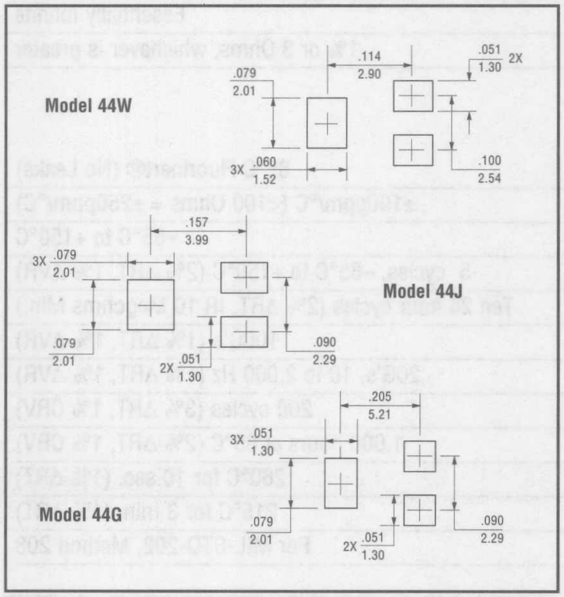


SIDE ADJUSTMENT





SOLDER PAD LAYOUT



FEATURES AND BENEFITS

- Space saving SMD design for the most compact board designs
- Sealed to withstand aggressive water wash
- Long life - set and forget construction
- BI quality and reliability
- Available in top and side adjustment versions, J-Hook or gull wing termination

PACKAGING

Standard: Embossed Tape & Reel
All units oriented with #1 pin to the right of the direction of feed

			13" Reel	7" Reel	
	Pin Style		G, J, W	G & J	W
Tape	Width	=	16 mm	12 mm	16 mm
	Sprocket	=	4 mm Pitch	4 mm Pitch	4 mm Pitch
	Capacity	=	1,000 Units	500 Units	250 Units
Reel	Diameter	=	13" (330.2 mm)	7" (178 mm)	7" (178 mm)

Option: Anti-Static Tubes
All units oriented with #1 pin to same side

Magazine Capacity, Units = 100

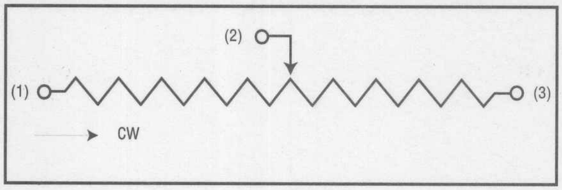
ORDERING INFORMATION

44 G R 10K XX *

- 44 — Model Series
- G — Lead Style
- R — Resistance Prefix
- 10K — Resistance Value
- XX — Packaging Option
  - TB = Tubes
  - T7 = 7" Tape & Reel
  - T13 = 13" Tape & Reel

* **Packaging option must be specified**

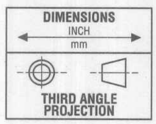
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

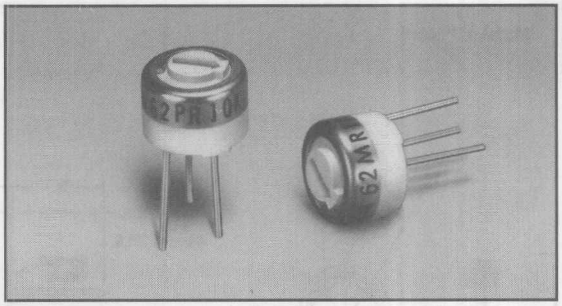
Tolerances unless otherwise specified:
Linear = ± .012 inches (.30mm)
Angular = ± 2 degrees



MODEL 62

1/4" Diameter Single Turn Cermet Trimming Potentiometer

Distributor Item



ELECTRICAL

Standard Resistance Range, Ohms	10 to 1Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 70°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Nominal	220°
Dielectric Strength	600Vrms
Insulation Resistance, Minimum	100 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (2% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Solid
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.02 oz. (0.50 grams)

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

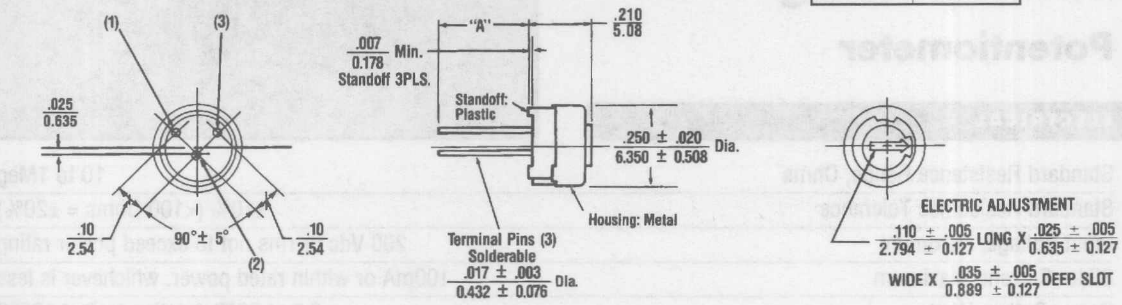
STANDARD RESISTANCE VALUES, OHMS

10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	
100	2K	25K	250K	

TOP ADJUSTMENT

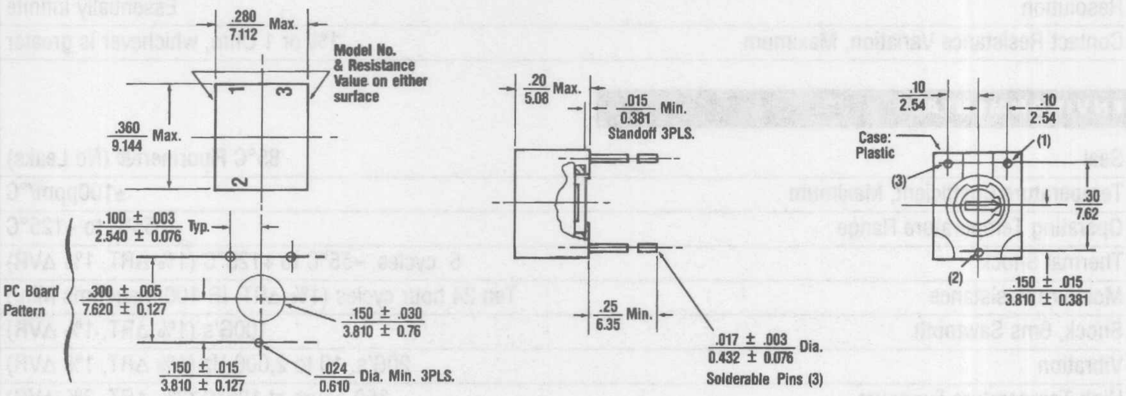
Model 62P, 62PF

Model No.	Dim "A"
62P	.312±.06 7.92±1.57
62PF	.625 / 15.87 Min.

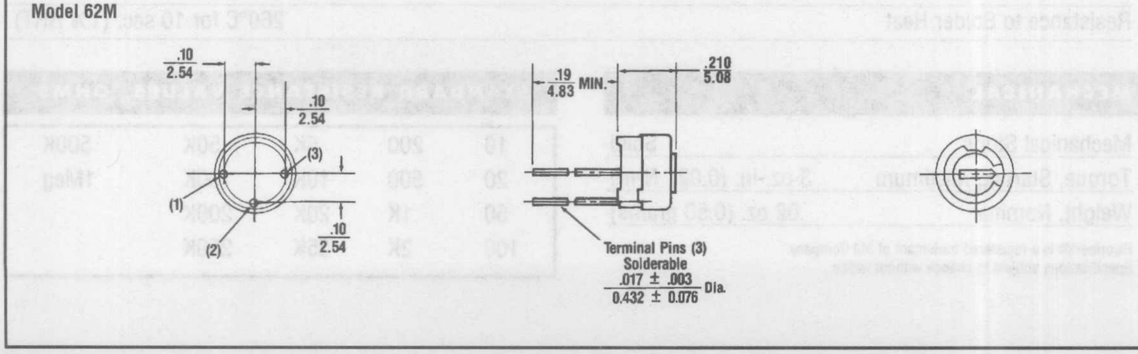


Note: Model 62P dimensions applicable to all other models except as noted

Model 62B



Model 62M



PACKAGING

Standard: Plastic Bags

	Capacity, Units	=	100

Option: Tubes (62P and 62M only)
All Units oriented with #1 pin to same side

Magazine	Width	=	0.34"
	Height	=	0.65"
	Length	=	27.5"
	Capacity, Units	=	100

ORDERING INFORMATION

Standard:

62 P R 10K

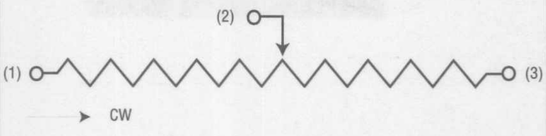
- Model Series — 62
- Pin Style — P
- Resistance Prefix — R
- Resistance Value — 10K

Option:

62 P R 10K TB

- Pin Style — P
- Packaging Option — TB
TB = Tubes

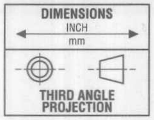
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

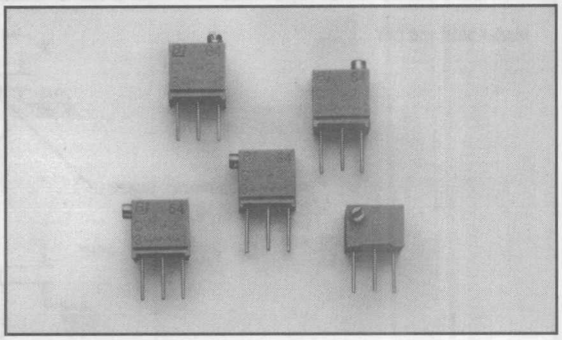


MODEL 64

1/4" Square Multi-Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 1Meg
Standard Resistance Tolerance	±10%
Input Voltage, Maximum	200Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.25 at 85°C derating to 0 at 150°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	15
Dielectric Strength	900Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–65°C to +150°C
Thermal Shock	5 cycles, –65°C to +150°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 1,000 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (2% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 85°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Clutch action, both ends
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.014 oz. (.40 grams)

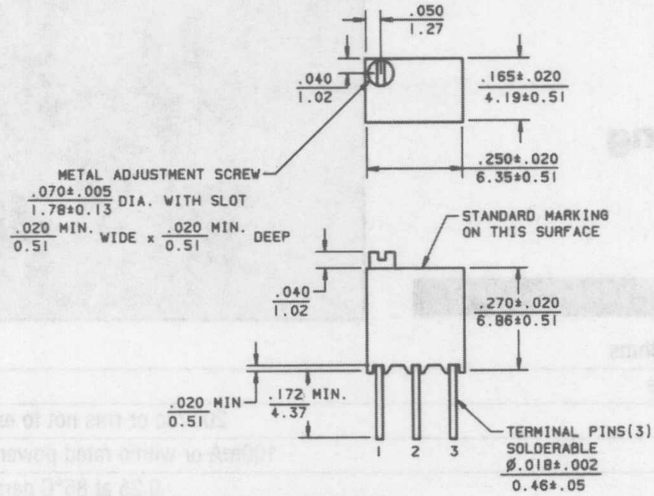
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

10	100	1K	10K	50K	250K
20	200	2K	20K	100K	500K
50	500	5K	25K	200K	1Meg

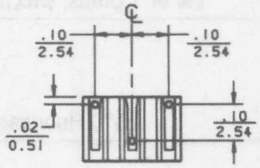
TOP ADJUSTMENT

Model 64W and 64Y

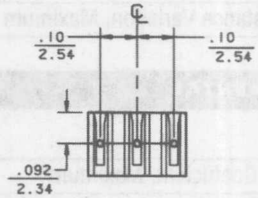


Note: Model 64W dimentions applicable to all models except as noted

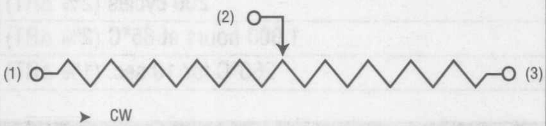
Model 64W



Model 64Y



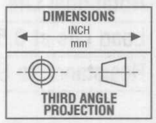
CIRCUIT DIAGRAM



NOTES

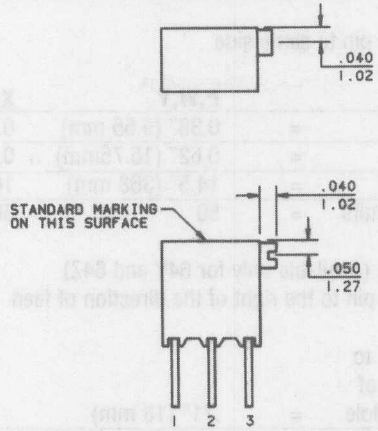
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original. English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

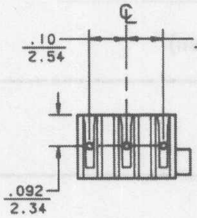


SIDE ADJUSTMENT

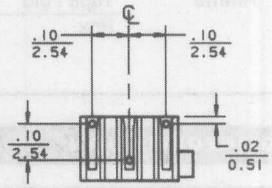
Model 64X and 64Z



Model 64Z

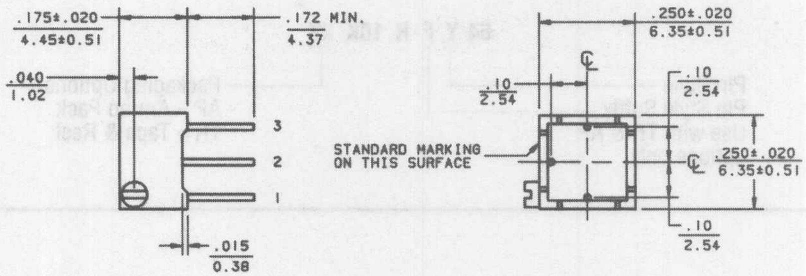


Model 64X



SIDE ADJUSTMENT

Model 64P



PACKAGING

Standard: Tubes
All Units oriented with #1 pin to same side

	Pin Style		P,W,Y	X,Z
Magazine	Width	=	0.38" (9.65 mm)	0.38" (9.65 mm)
	Height	=	0.62" (15.75mm)	0.62" (15.75mm)
	Length	=	14.5" (368 mm)	16.9" (429 mm)
	Capacity Units	=	50	50

Option: Tape & Reel, Ammo Pack (Available only for 64Y and 64Z)
All units oriented with #1 pin to the right of the direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (363 mm)
Ammo	Tape Fold	=	12"
	Box	=	1.8" x 13" x 10" (46mm x 330mm x 254mm)

ORDERING INFORMATION

Standard:

64 P R 10K

Model Series — 64
Pin Style — P
Resistance Prefix — R
Resistance Value — 10K

Option:

64 Y F R 10K XX

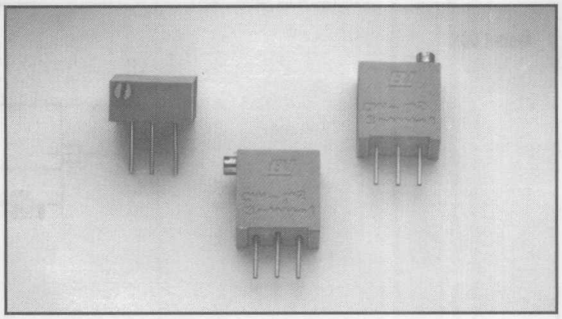
Pin Style — Y
Pin Style Suffix — F
Use with TR & AP options only
Packaging Options — XX
AP = Ammo Pack
TR = Tape & Reel

MODEL 66

3/8" Square Multi-Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 70°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	20
Dielectric Strength	1,000 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–65°C to +150°C
Thermal Shock	5 cycles, –65°C to +150°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 1,000 Megohms min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Clutch Action, both ends
Torque, Starting Maximum	5 oz.-in. (0.035 N-m)
Weight, Nominal	.04 oz. (1.13 grams)

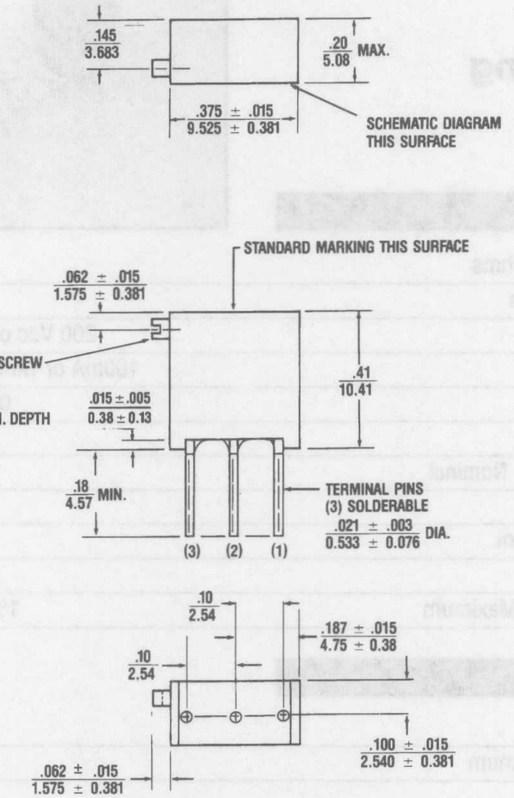
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

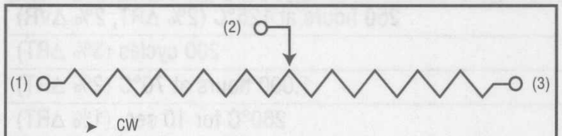
10	200	5K	50K	500
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

SIDE ADJUSTMENT

Model 66X



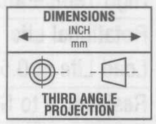
CIRCUIT DIAGRAM



NOTES

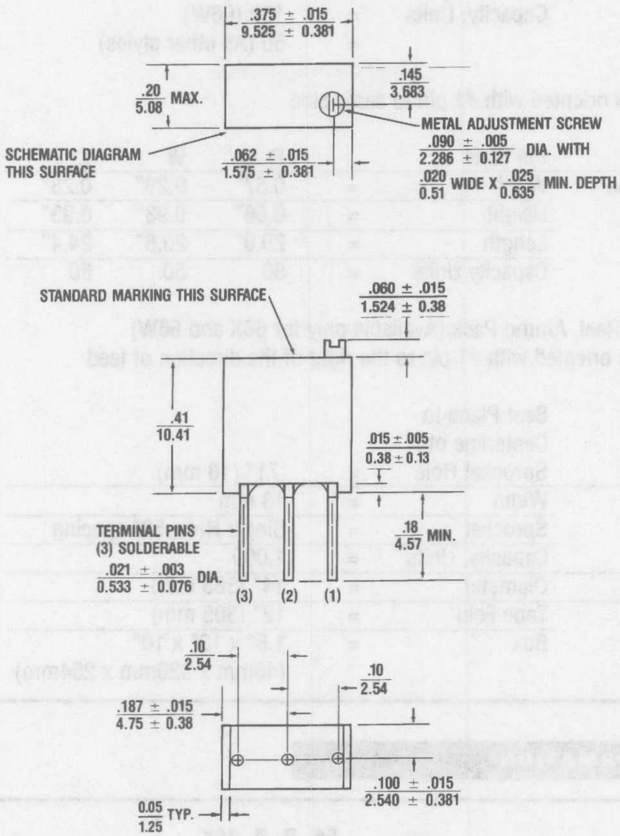
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



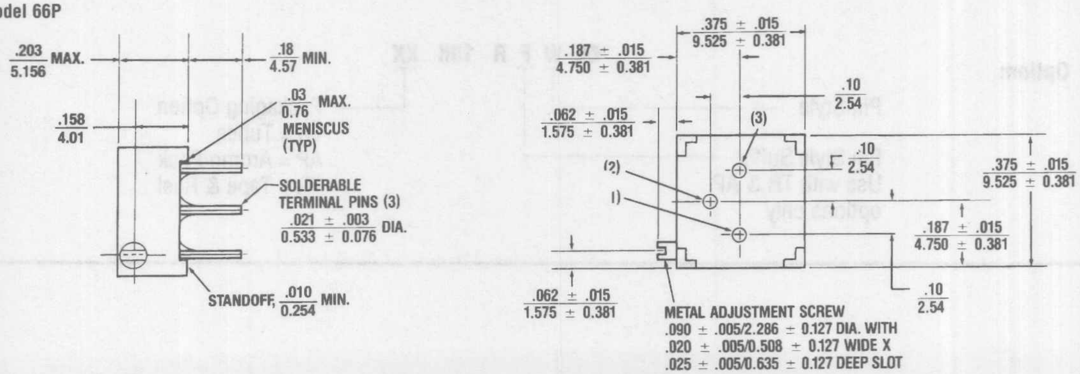
TOP ADJUSTMENT

Model 66W



SIDE ADJUSTMENT

Model 66P



PACKAGING

Standard: Boxes

	Capacity, Units	=	100 (66W)
		=	50 (All other styles)

Option: Tubes

All Units oriented with #1 pin to same side

	Pin Style		P	W	X
Magazine	Width	=	0.57"	0.28"	0.28"
	Height	=	0.66"	0.93"	0.93"
	Length	=	20.9"	20.6"	24.4"
	Capacity Units	=	50	50	50

Option: Tape & Reel, Ammo Pack (Available only for 66X and 66W)

All units oriented with #1 pin to the right of the direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (363 mm)
Ammo	Tape Fold	=	12" (305 mm)
	Box	=	1.8" x 13" x 10" (46mm x 330mm x 254mm)

ORDERING INFORMATION

Standard: **66 P R 10K**

Model Series

Pin Style

Resistance Value

Resistance Prefix

Option: **66 W F R 10K XX**

Pin Style

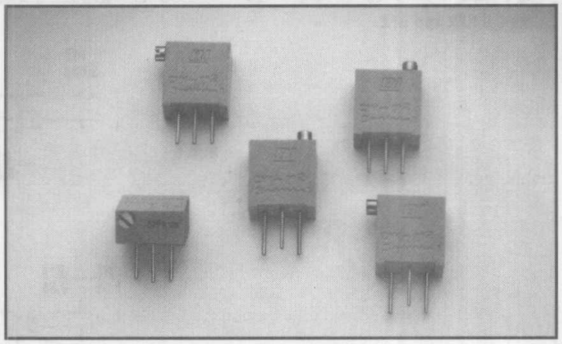
Pin Style Suffix
Use with TR & AP
options only

Packaging Option
TB = Tubes
AP = Ammo Pack
TR = Tape & Reel

MODEL 67

3/8″ Square Multi-Turn Cermet Trimming Potentiometer

Distributor Item



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 85°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	20
Dielectric Strength	900 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 1,000 Megohms min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Clutch Action, both ends
Torque, Starting Maximum	5 oz.-in. (0.035 N-m)
Weight, Nominal	.04 oz. (1.13 grams)

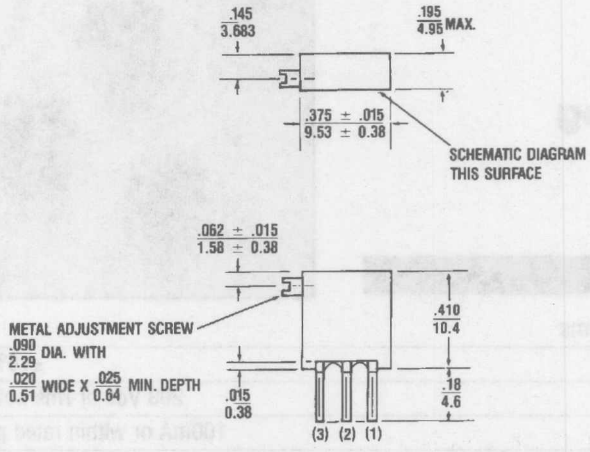
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

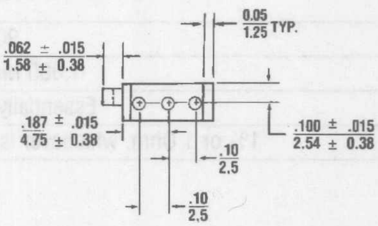
10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

SIDE ADJUSTMENT

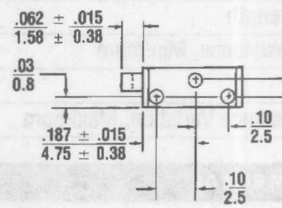
Model 67X and 67Z



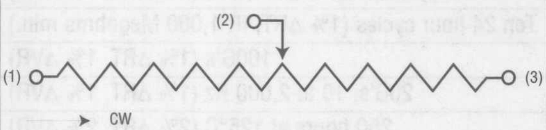
Model 67X



Model 67Z



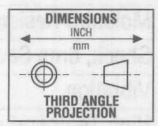
CIRCUIT DIAGRAM



NOTES

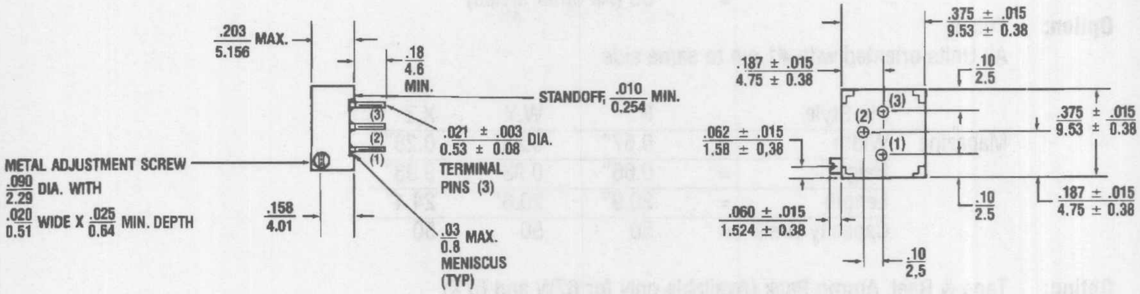
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



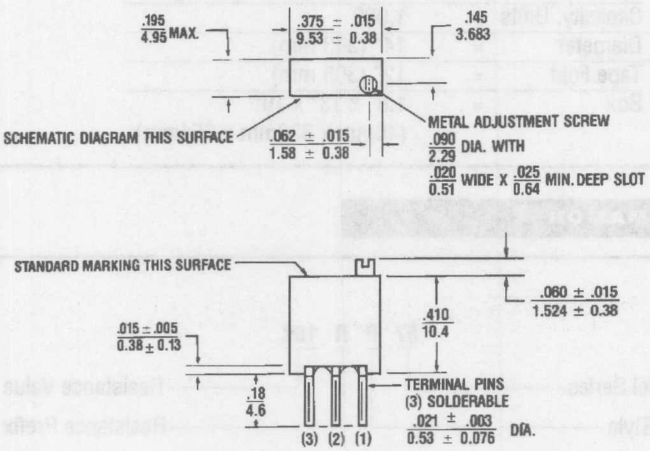
SIDE ADJUSTMENT

Model 67P

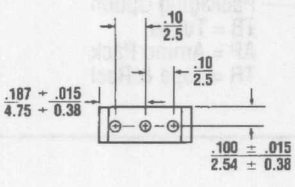


TOP ADJUSTMENT

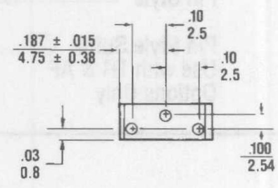
Model 67W and 67Y



Model 67W



Model 67Y



PACKAGING

Standard: Boxes

Capacity, Units	=	100 (67W)
	=	50 (All other styles)

Option: Tubes
All Units oriented with #1 pin to same side

	Pin Style		P	W,Y	X,Z
Magazine	Width	=	0.57"	0.28"	0.28"
	Height	=	0.66"	0.93"	0.93"
	Length	=	20.9"	20.6"	24.4"
	Capacity Units	=	50	50	50

Option: Tape & Reel, Ammo Pack (Available only for 67W and 67X)
All units oriented with #1 pin to the right of the direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18.03 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (363 mm)
Ammo	Tape Fold	=	12" (305 mm)
	Box	=	1.8" x 13" x 10" (46mm x 330mm x 254mm)

ORDERING INFORMATION

Standard:

67 P R 10K

Model Series — 67
Pin Style — P
Resistance Prefix — R
Resistance Value — 10K

Option:

67 W F R 10K XX

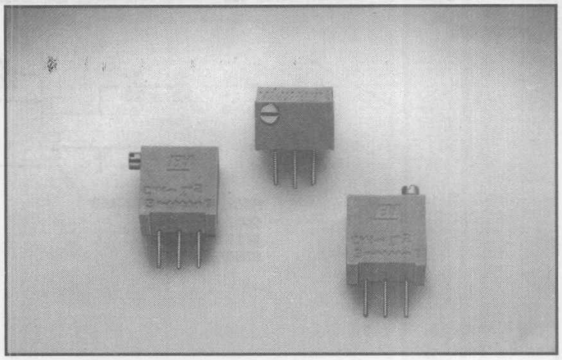
Pin Style — W
Pin Style Suffix — F
Use with TR & AP
Options Only
Packaging Option — XX
TB = Tubes
AP = Ammo Pack
TR = Tape & Reel

MODEL 68

3/8" Square Multi-Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 85°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	20
Dielectric Strength	900 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 1,000 Megohms min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Clutch Action, both ends
Torque, Starting Maximum	5 oz.-in. (0.035 N-m)
Weight, Nominal	.04 oz. (1.13 grams)

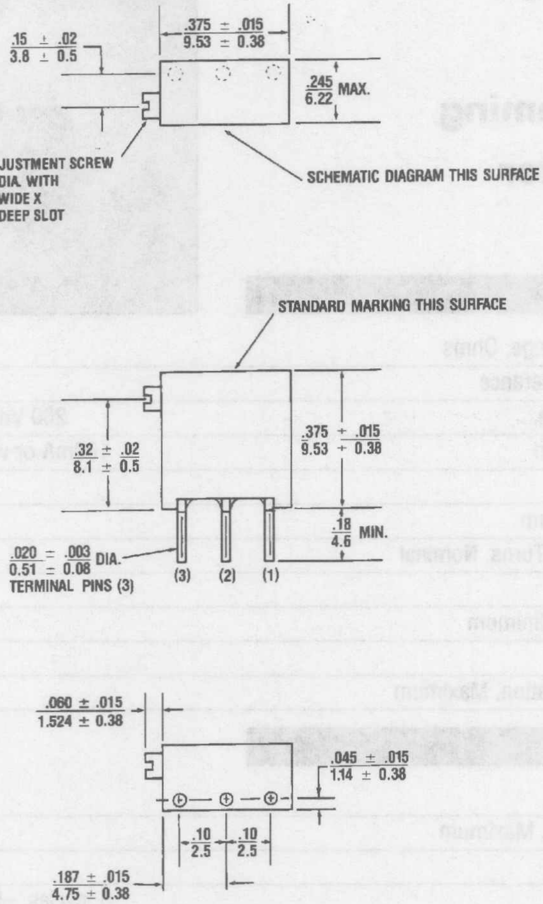
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

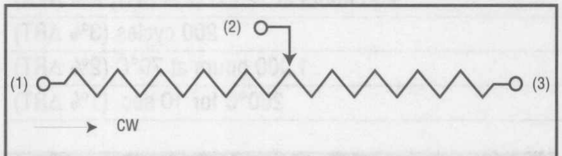
10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

SIDE ADJUSTMENT

Model 68X



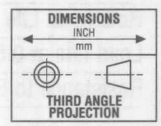
CIRCUIT DIAGRAM



NOTES

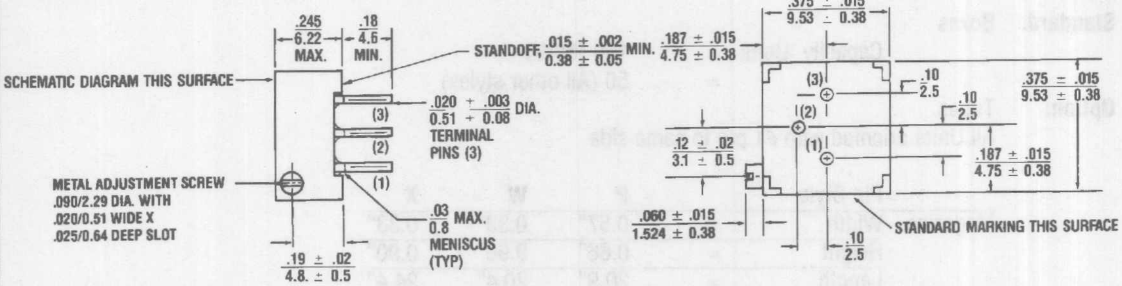
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



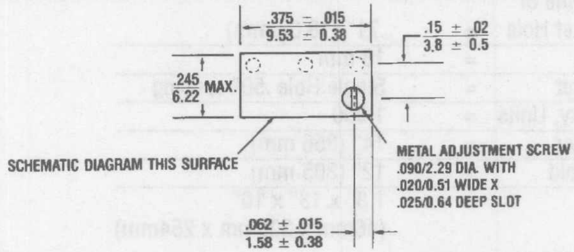
SIDE ADJUSTMENT

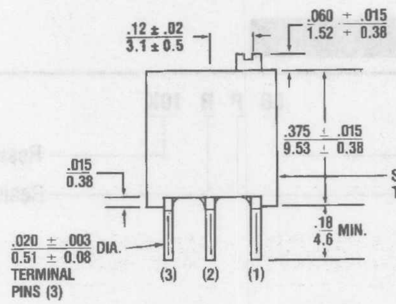
Model 68P

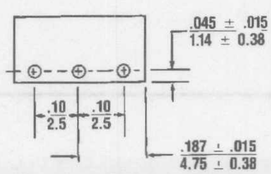


TOP ADJUSTMENT

Model 68W







PACKAGING

Standard: Boxes

Capacity, Units	=	100 (68W)
	=	50 (All other styles)

Option: Tubes
All Units oriented with #1 pin to same side

	Pin Style		P	W	X
Magazine	Width	=	0.57"	0.33"	0.33"
	Height	=	0.66"	0.90"	0.90"
	Length	=	20.9"	20.4"	24.4"
	Capacity Units	=	50	50	50

Option: Tape & Reel, Ammo Pack (Available only for 68W and 68X)
All units oriented with #1 pin to the right of the direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18.03 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (356 mm)
Ammo	Tape Fold	=	12" (305 mm)
	Box	=	1.8" x 13" x 10" (46mm x 330mm x 254mm)

ORDERING INFORMATION

Standard:

68 P R 10K

- 68 — Model Series
- P — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value

Option:

68 W R 10K TB

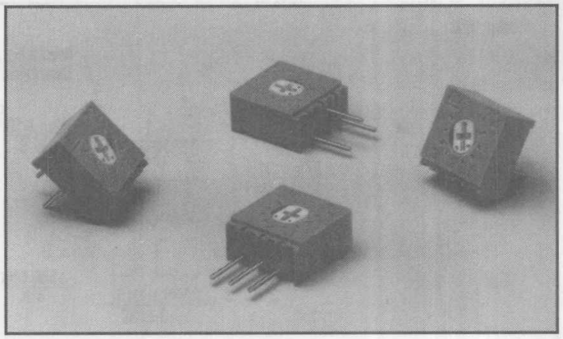
- W — Pin Style
- TB — Packaging Option, TB = Tubes

MODEL 72

Distributor Item

1

3/8" Square Single Turn Cermet Trimming Potentiometer



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 85°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Nominal	244°
Dielectric Strength	900 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

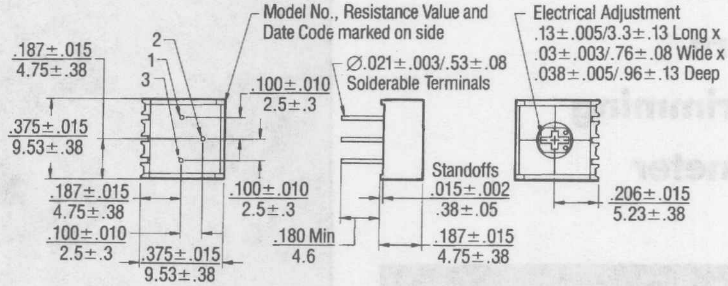
Mechanical Stops	Solid
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.025 oz. (0.70 grams)

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

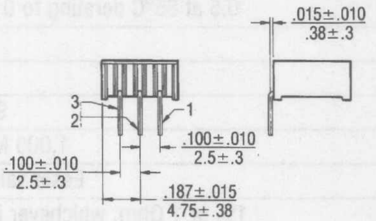
10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

Model 72P

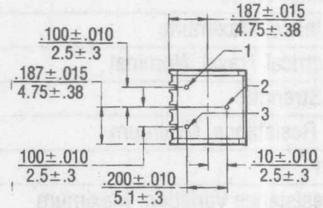


Note: Model 72P dimensions applicable to all other models except as noted

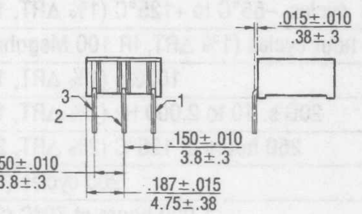
Model 72PL



Model 72PM

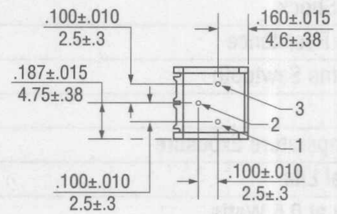


Model 72PX, 72RPX



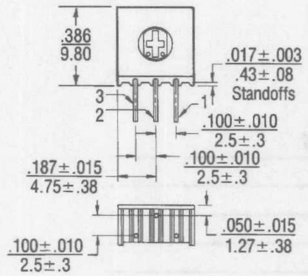
Model 72RPX - Terminals 1 and 3 are reversed

Model 72RP



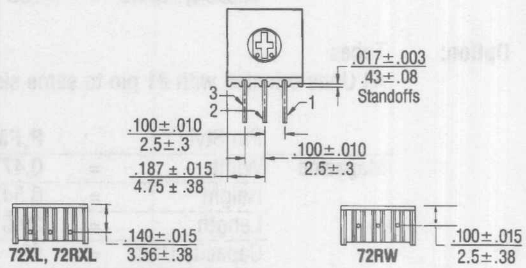
SIDE ADJUSTMENT

Model 72X, 72RX



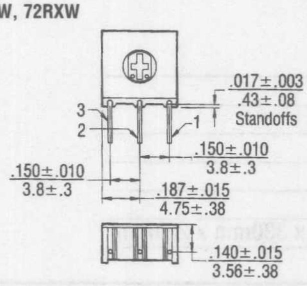
Model 72RX - Terminals 1 and 3 are reversed

Model 72XL, 72RXL, 72RW



Model 72RXL and 72RW - Terminals 1 and 3 are reversed

Model 72XW, 72RXW



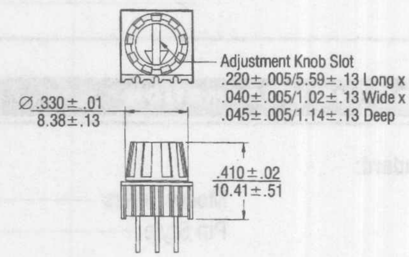
Model 72RXW - Terminals 1 and 3 are reversed

ADJUSTMENT KNOB OPTION

Available options:

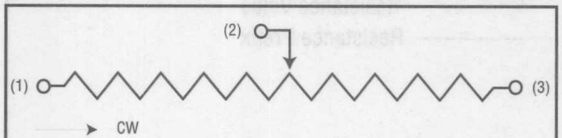
72XT- Side Adjustment
(See 72X for Pin Configuration)

72PT- Top Adjustment
(See 72P for Pin Configuration)



72PT Shown - Dimensions applicable to 72XT

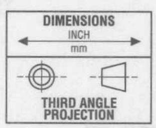
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



PACKAGING

Standard: Plastic Bags

Capacity, Units = 100

Option: Tubes

All Units oriented with #1 pin to same side

	Pin Style		P,PM	X,XL,XW,RW
Magazine	Width	=	0.47"	0.29"
	Height	=	0.54"	0.76"
	Length	=	20.5"	20.1"
	Capacity Units	=	50	50

Option: Tape & Reel, Ammo Pack (Available only for 72RW only)

All units oriented with #1 pin to the right of the direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18.03 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (356mm)
Ammo	Tape Fold	=	12" (305mm)
	Box	=	1.8" x 13" x 10" (46mm x 330mm x 254mm)

ORDERING INFORMATION

Standard:

72 P R 10K

- 72 — Model Series
- P — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value

Options:

72 P R 10K TB

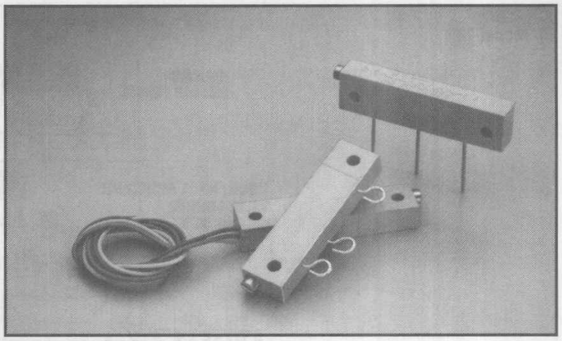
- P — Pin Style
- TB — Packaging Option
  TB = Tubes

72 RW F R 10K XX

- RW — Pin Style
- F — Pin Style Suffix
  Use with TR & AP options only
- XX — Packaging Options
  TB = Tubes
  AP = Ammo Pack
  TR = Tape & Reel

MODEL 78

1-1/4" Rectangular Multi-Turn Cermet Trimming Potentiometer



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	300 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	1.0 at 70°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	22
Dielectric Strength	500 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 1,000 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Clutch Action, both ends
Torque, Starting Maximum	5oz.-in. (0.035 N-m)
Weight, Nominal	.09 oz. (2.5 grams)

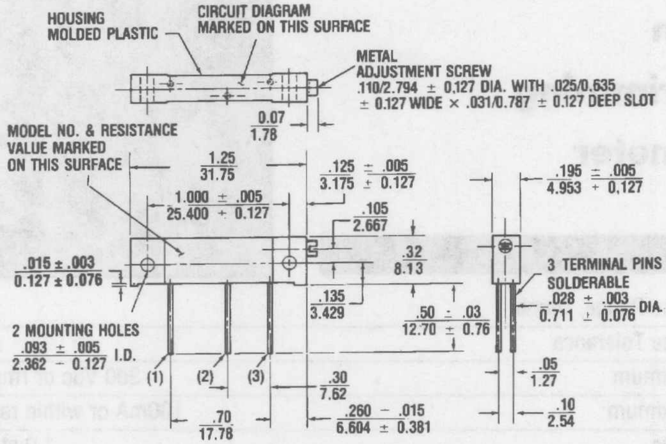
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

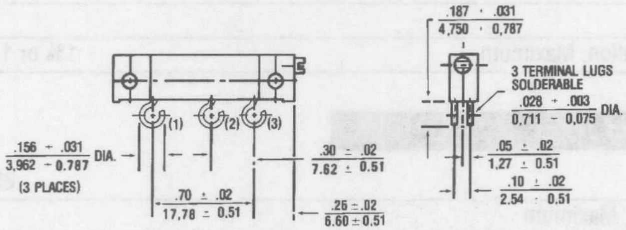
SIDE ADJUSTMENT

Model 78P

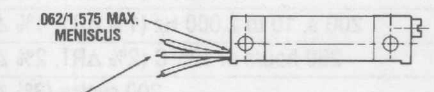


Note: Model 78P dimensions applicable to all other models except as noted

Model 78S



Model 78L



3 ELECTRICAL LEADS – 6/152 MIN. LENGTH
NO. 30 AWG TEFLON INSULATED STRANDED WIRE

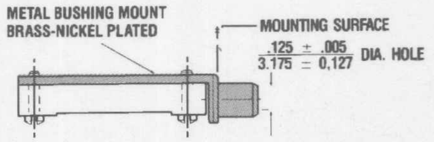
YELLOW (1)
RED (2)
GREEN (3)

PACKAGING

Standard:	Boxes		
	Capacity	=	25 Units

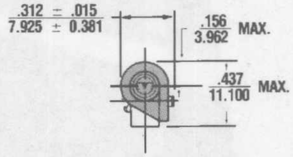
PANEL MOUNT ADAPTER

Model 56BW (Adapter Only)

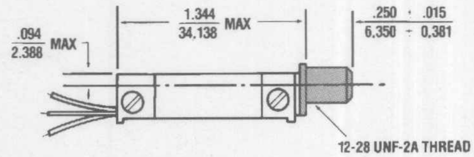


USE .22/5.613 DIA. MIN. MOUNTING HOLE

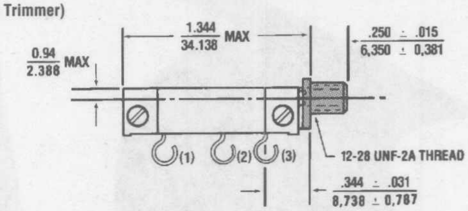
Lock Washer, Panel Nut, Sealing Washer
& Mounting Screws Provided



Model 78LBW (Adapter Pre-Assembled with Trimmer)



Model 78SBW (Adapter Pre-Assembled with Trimmer)



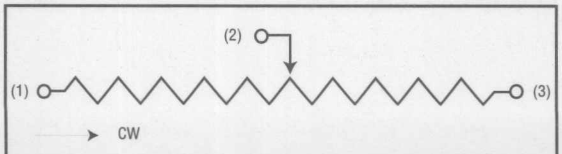
ORDERING INFORMATION

78 P BW R 10K

- 78 — Model Series
- P — Pin Style
- BW — Optional Panel Mount Adapter
- R — Resistance Prefix
- 10K — Resistance Value

Note: Use '56BW' to order panel mount adapter without trimmer

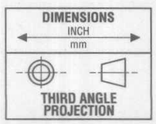
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

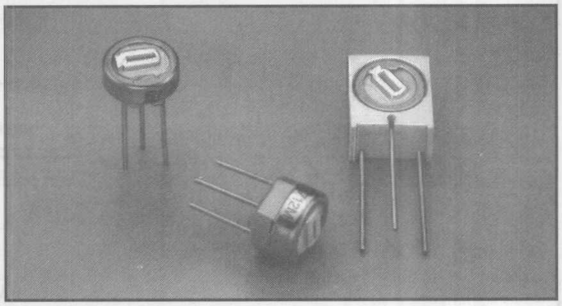


MODEL 82

1/4" Diameter Single Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 1Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 70°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Nominal	220°
Dielectric Strength	600 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1%ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Solid
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.02 oz. (0.50 grams)

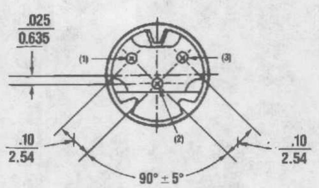
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

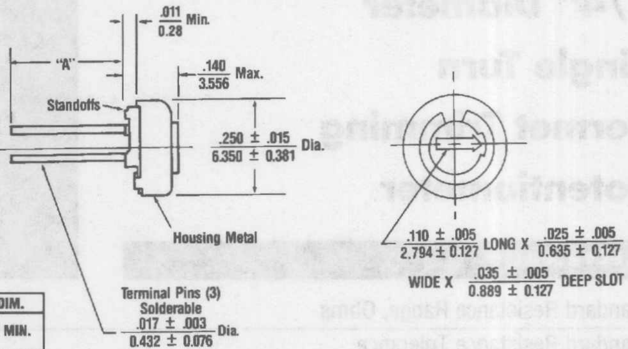
STANDARD RESISTANCE VALUES, OHMS

10	100	1K	10K	50K	250K
20	200	2K	20K	100K	500K
50	500	5K	25K	200K	1Meg

TOP ADJUSTMENT

Model 82P, 82PF

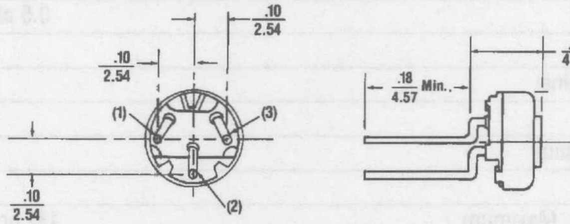




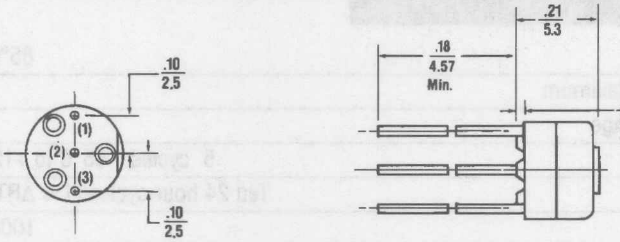
MODEL NO.	"A" DIM.
82P	.25 / 6.35 MIN.
82PF	.625 / 15.875 MIN.

Note: Model 82P dimensions applicable to all models except as noted

Model 82M

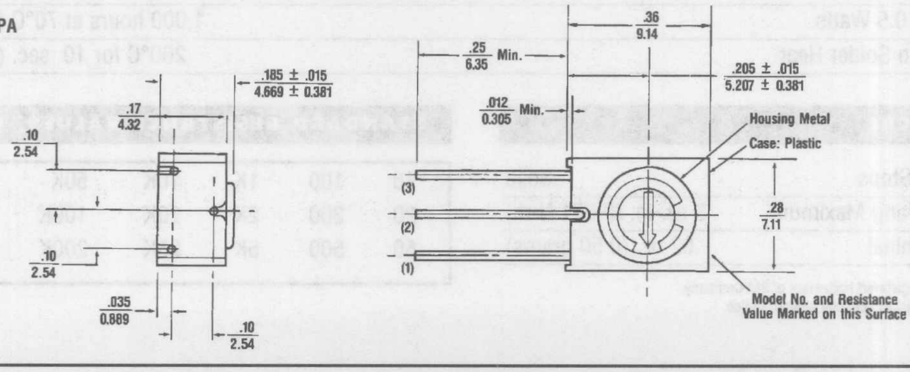


Model 82W



SIDE ADJUSTMENT

Model 82PA



PACKAGING

Standard: Plastic Bags

	Capacity, Units	=	50 (82PA, 82PF)	
		=	100 (All other styles)	

Option: Tubes
All Units oriented with #1 pin to same side

	Pin Style		**PA**	**P,M,W**
Magazine	Width	=	0.28"	0.34"
	Height	=	0.94"	0.65"
	Length	=	15.6"	27.5"
	Capacity, Units	=	50	100

Option: Tape & Reel, Ammo Pack (Available for 82W Only)
All units oriented with #1 pin to the right of the direction of feed

	Seat Plane to Centerline of Sprocket Hole	=	.71" (18.03 mm)
Tape	Width	=	18 mm
	Sprocket	=	Single Hole .50" spacing
	Capacity, Units	=	1,000
Reel	Diameter	=	14" (356 mm)
Ammo	Tape Fold	=	12" (305 mm)
	Box	=	1.5" x 13" x 10"

ORDERING INFORMATION

Standard:

82 P R 10K

Model Series — 82
Pin Style — P
Resistance Prefix — R
Resistance Value — 10K

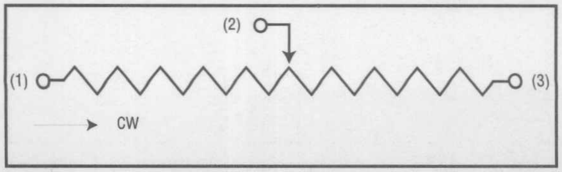
Option:

82 W F R 10K XX

Pin Style — W
Pin Style Suffix — F
Use with TR & AP
Options Only

Packaging Option — XX
TB = Tubes
AP = Ammo Pack
TR = Tape & Reel

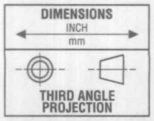
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

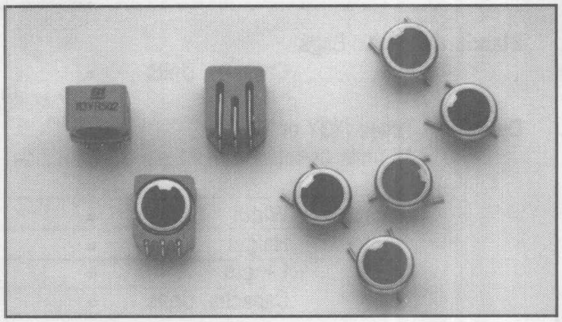


MODEL 83

1/4" Single Turn Surface Mount Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 1Meg
Standard Resistance Tolerance	±10%(<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 70°C derating to 0 at 150°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Nominal	220°
Dielectric Strength	400 Vrms
Insulation Resistance, Minimum	100 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, – 55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 1,000 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	350°C for 3 sec. (1% ΔRT) 260°C for 10 sec. (1% ΔRT) 215°C for 120 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Solid
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.03 oz. (0.85 grams)

STANDARD RESISTANCE VALUES, OHMS

10	100	1K	10K	50K	250K
20	200	2K	20K	100K	500K
50	500	5K	25K	200K	1Meg

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

PACKAGING

Standard: Plastic Bags

	Capacity, Units	=	100

Option: Tubes (83Y only)
All units oriented with #1 pin to same side

Magazine:	Width	=	0.30"
	Height	=	0.35"
	Length	=	19.1"
	Capacity, Units	=	50

Option: Embossed Tape & Reel (83P only)
All units oriented with #1 pin to the right of the direction of feed

Tape:	Width	=	16 mm
	Sprocket	=	4 mm pitch
	Capacity, Units	=	1,000
Reel:	Diameter	=	14" (356 mm)

ORDERING INFORMATION

Standard:

83 P R 10K

Model Series — 83
Pin Style — P
Resistance Prefix — R
Resistance Value — 10K

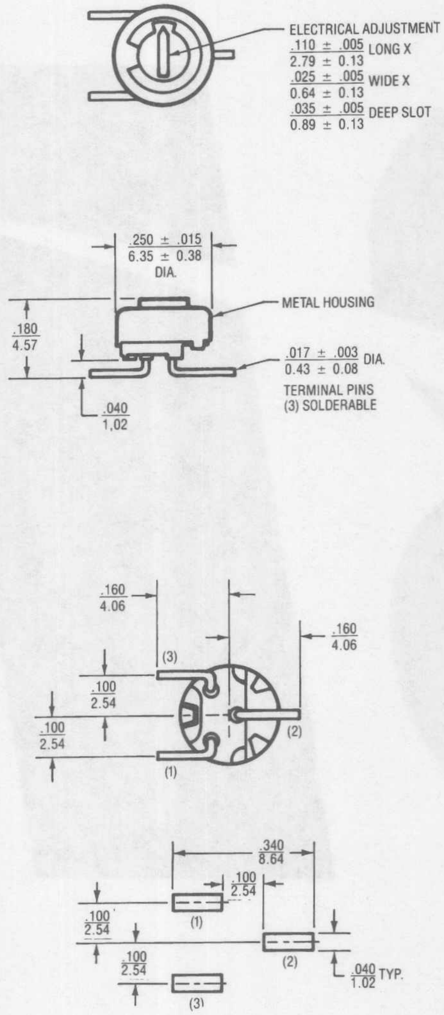
Special Options:

83 P R 10K XX

Pin Style — P
Packaging Option — XX
TB = Tubes (83Y only)
TR = Tape & Reel (83P only)

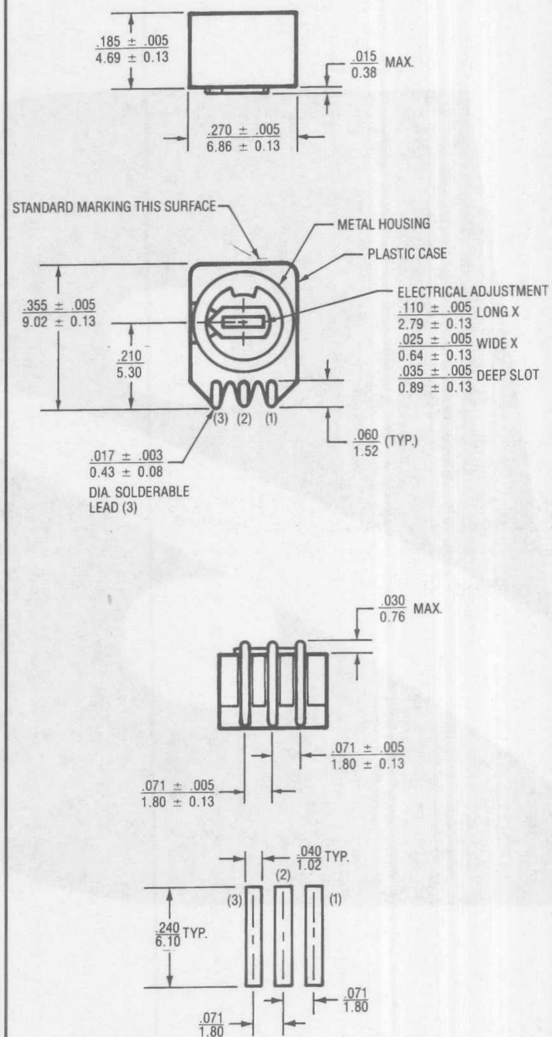
TOP ADJUSTMENT

Model 83P

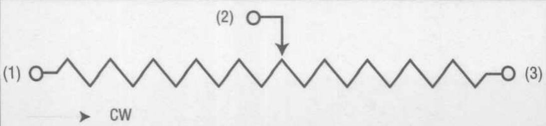


SIDE ADJUSTMENT

Model 83Y

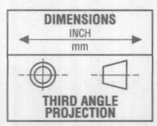


CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.



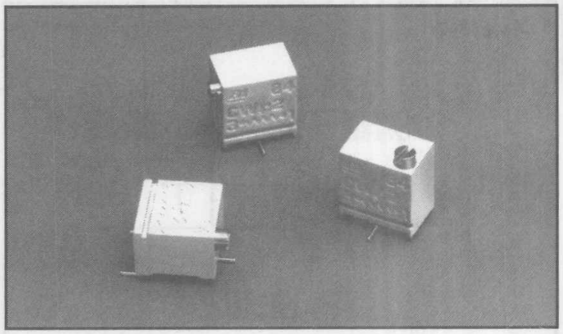
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

MODEL 84

1/4" Square Multi-Turn Surface Mount Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 1Meg
Standard Resistance Tolerance	±10%
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.25 at 85°C derating to 0 at 150°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	15
Dielectric Strength	900 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohms, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Operating Temperature Range	–65°C to +150°C
Thermal Shock	5 cycles, –65°C to +150°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 150°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 85°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)
Temperature Exposure, Maximum	215°C for 3 min. (1% ΔRT)

MECHANICAL

Mechanical Stops	Clutch action, both ends
Torque, Starting Maximum	3 oz.-in. (0.021 N-m)
Weight, Nominal	.014 oz. (.40 grams)

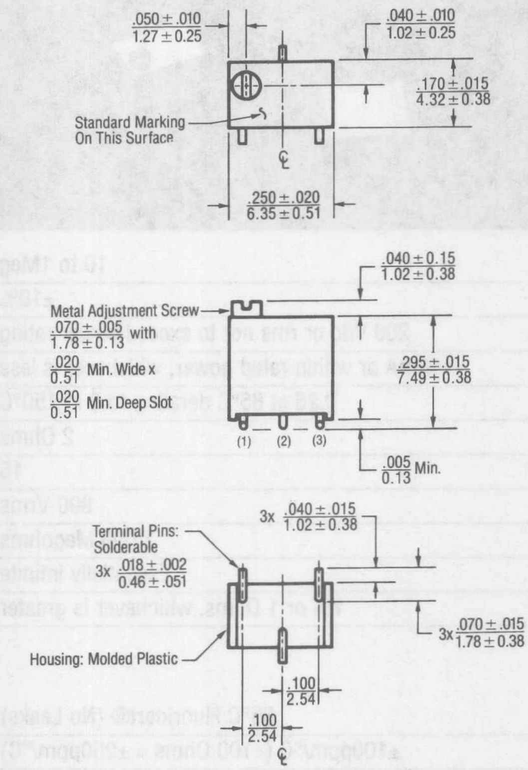
Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

10	100	1K	10K	50K	250K
20	200	2K	20K	100K	500K
50	500	5K	25K	200K	1Meg

TOP ADJUSTMENT

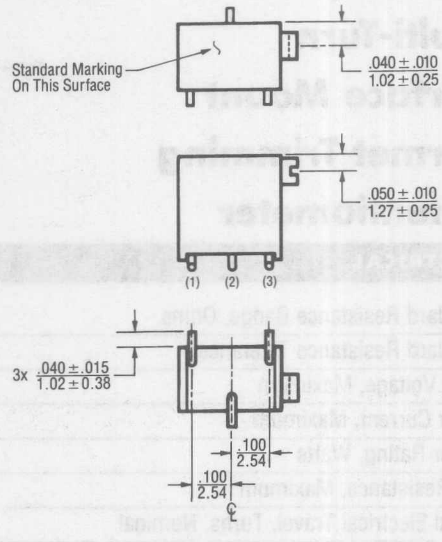
Model 84W



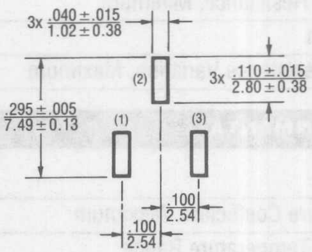
Note: Model 84W dimensions applicable to all models except as noted

SIDE ADJUSTMENT

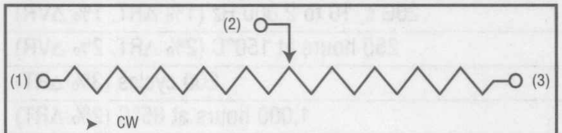
Model 84X



Recommended PCB Layout- Model 84W and 84X



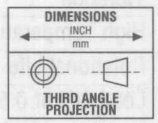
CIRCUIT DIAGRAM



NOTES

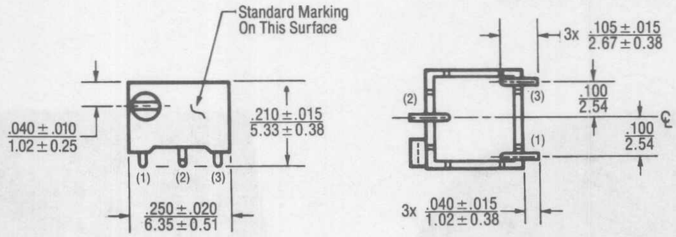
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

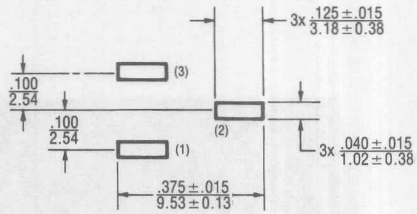


SIDE ADJUSTMENT

Model 84P



Recommended PCB Layout- Model 84P



PACKAGING

Standard: Tubes
All Units oriented with #1 pin to same side

	Pin Style		P	W/X
Magazine	Width	=	0.47"(11.93mm)	0.37"(9.39mm)
	Height	=	0.32"(8.13mm)	0.47"(11.93mm)
	Length	=	14.5"(368mm)	14.5"(368mm) 16.5"(429mm)
	Capacity Units	=	50	50

Option: Embossed Tape & Reel (84P & 84W only)
All units oriented with #1 pin to the right of the direction of feed

	Pin Style	=	P	W/X
Tape	Width	=	16 mm	24mm
	Sprocket	=	4 mm pitch	4mm pitch
	Capacity, Units	=	500	400
Reel	Diameter	=	13" (330 mm)	13" (330mm)

ORDERING INFORMATION

Standard: **84 P R 10K XX**

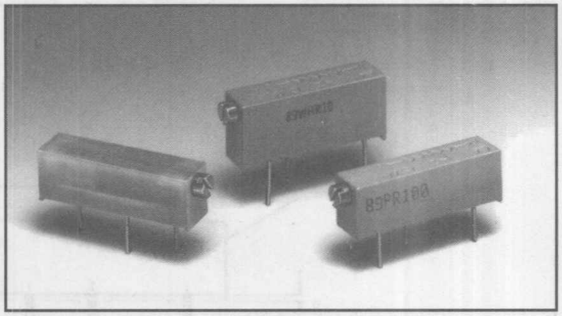
- 84 — Model Series
- P — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value
- XX — Packaging Option, TR = Tape & Reel

MODEL 89

3/4" Rectangular Multi-Turn Cermet Trimming Potentiometer

Distributor Item

1



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.75 at 85°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Turns, Nominal	20
Dielectric Strength	1,000 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

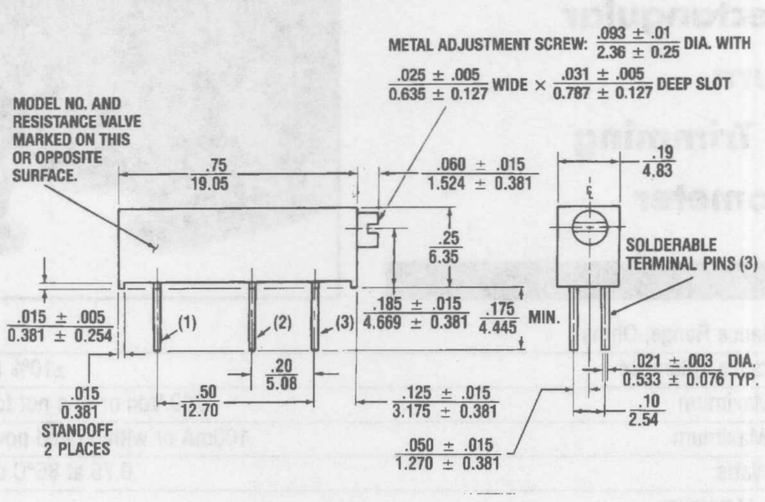
Mechanical Stops	Clutch Action, both ends
Torque, Starting Maximum	5 oz.-in. (0.035 N-m)
Weight, Nominal	.05 oz. (1.4 grams)

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

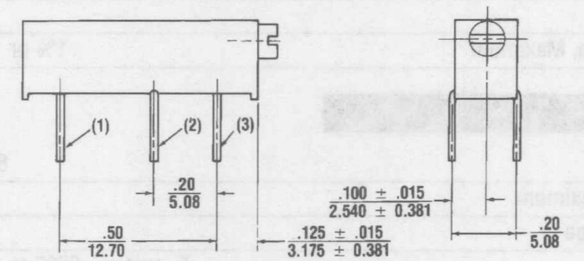
10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

Model 89P and 90P

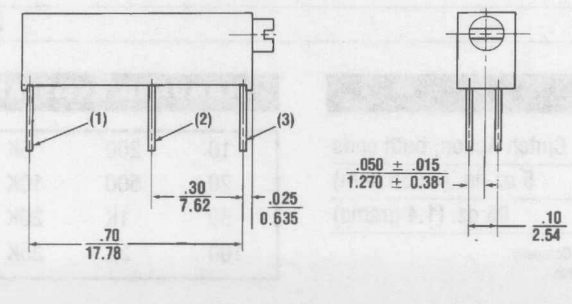


Note: Model 89P dimensions applicable to all other models except as noted

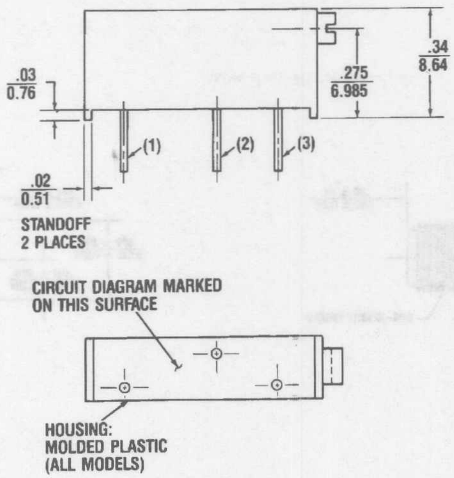
Model 89W



Model 89X

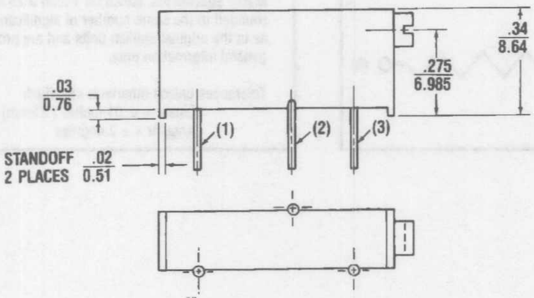


Model 89PH



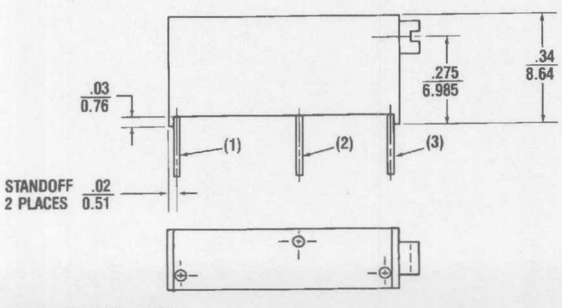
Pin dimensions same for 89P and 89PH

Model 89WH



Pin dimensions same for 89W and 89WH

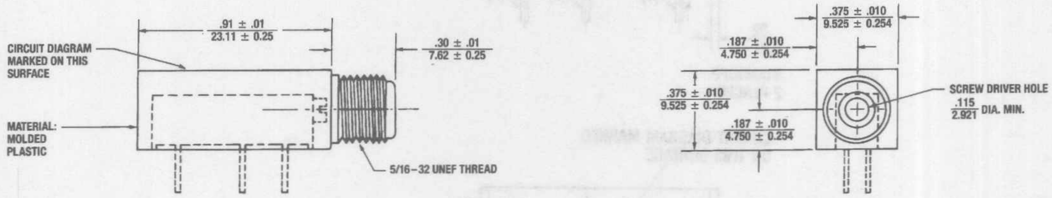
Model 89XH



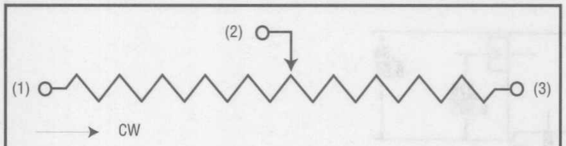
Pin dimensions same for 89X and 89XH

PANEL MOUNT ADAPTER

Model 89B



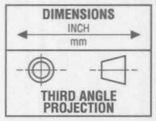
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



PACKAGING

Standard: Plastic Bags

	Capacity, Units	=	100 (89P) 50 (All other styles)

Option: Tubes
All Units oriented with #1 pin to same side

Magazine	Width	=	0.28"
	Height	=	0.65"
	Length	=	21.5"
	Capacity, Units	=	25

ORDERING INFORMATION

Standard:

89 P R 10K

- 89 — Model Series (Use Model 90 to order with transparent housing)
- P — Pin Style
- R — Resistance Prefix
- 10K — Resistance Value

Option:

89 P R 10K TB

- 89 — Pin Style
- TB — Packaging Option, TB = Tubes

Option:

89 P B R 10K

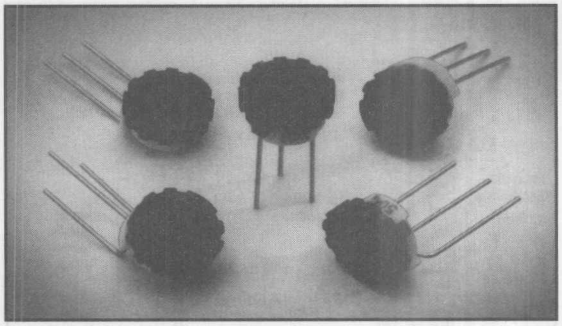
- 89 — Model Series
- B — Panel Mount Adapter (Use 89B to order Adapter without Trimmer)

MODEL 91

Distributor Item

1

3/8" Diameter Single Turn Cermet Trimming Potentiometer



ELECTRICAL

Standard Resistance Range, Ohms	10 to 2Meg
Standard Resistance Tolerance	±20%
Input Voltage, Maximum	250 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	0.5 at 70°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Nominal	174°
Dielectric Strength	500 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

Mechanical Stops	Solid
Stop Strength	12 oz.-in. (0.085 N-m)
Torque, Starting Maximum	5oz.-in. (0.042 N-m)
Weight, Nominal	.03 oz. (0.85 grams)

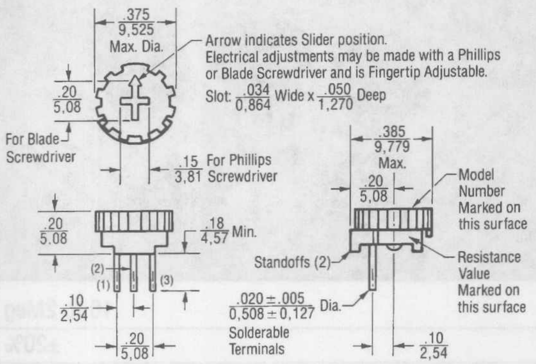
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

10	200	5K	50K	500K
20	500	10K	100K	1Meg
50	1K	20K	200K	2Meg
100	2K	25K	250K	

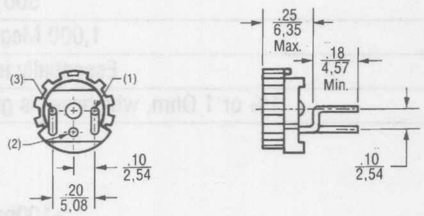
TOP ADJUSTMENT

Model 91A

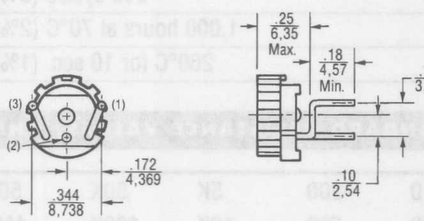


Note: Model 91A dimensions applicable to all models except as noted

Model 91B

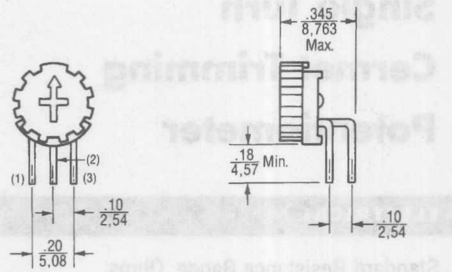


Model 91C

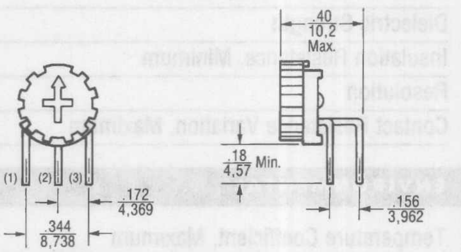


SIDE ADJUSTMENT

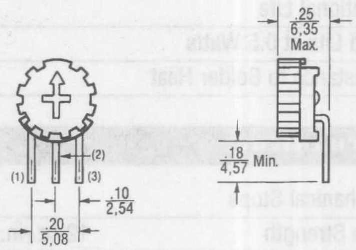
Model 91T



Model 91V

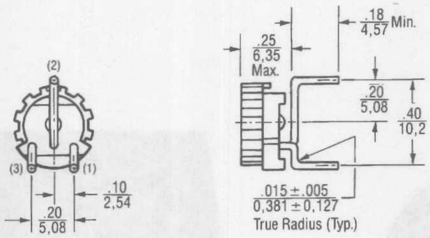


Model 91W



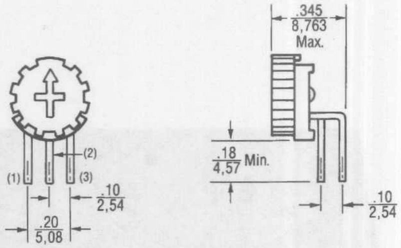
TOP ADJUSTMENT

Model 91E



SIDE ADJUSTMENT

Model 91X



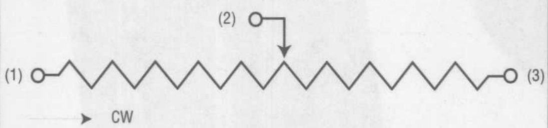
ORDERING INFORMATION

Standard:

91 A R 10K

Model Series — 91
Pin Style — A
Resistance Prefix — R
Resistance Value — 10K

CIRCUIT DIAGRAM



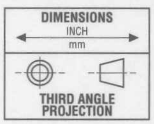
PACKAGING

Standard: Plastic Bags
Capacity, Units = 100

NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

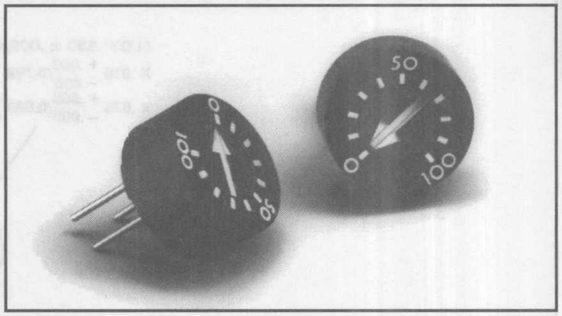
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL 93

1/2" Diameter Single Turn Cermet Trimming Potentiometer

Distributor Item



ELECTRICAL

Standard Resistance Range, Ohms	20 to 2Meg
Standard Resistance Tolerance	±10% (<100 Ohms = ±20%)
Input Voltage, Maximum	200 Vdc or rms not to exceed power rating
Slider Current, Maximum	100mA or within rated power, whichever is less
Power Rating, Watts	1.0 at 70°C derating to 0 at 125°C
End Resistance, Maximum	2 Ohms
Actual Electrical Travel, Nominal	270°
Dielectric Strength	900 Vrms
Insulation Resistance, Minimum	1,000 Megohms
Resolution	Essentially infinite
Contact Resistance Variation, Maximum	1% or 1 Ohm, whichever is greater

ENVIRONMENTAL

Seal	85°C Fluorinert® (No Leaks)
Temperature Coefficient, Maximum	±100ppm/°C
Operating Temperature Range	–55°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (1% ΔRT, 1% ΔVR)
Moisture Resistance	Ten 24 hour cycles (1% ΔRT, IR 100 Megohms Min.)
Shock, 6ms Sawtooth	100G's (1% ΔRT, 1% ΔVR)
Vibration	20G's, 10 to 2,000 Hz (1% ΔRT, 1% ΔVR)
High Temperature Exposure	250 hours at 125°C (2% ΔRT, 2% ΔVR)
Rotational Life	200 cycles (3% ΔRT)
Load Life at 0.5 Watts	1,000 hours at 70°C (2% ΔRT)
Resistance to Solder Heat	260°C for 10 sec. (1% ΔRT)

MECHANICAL

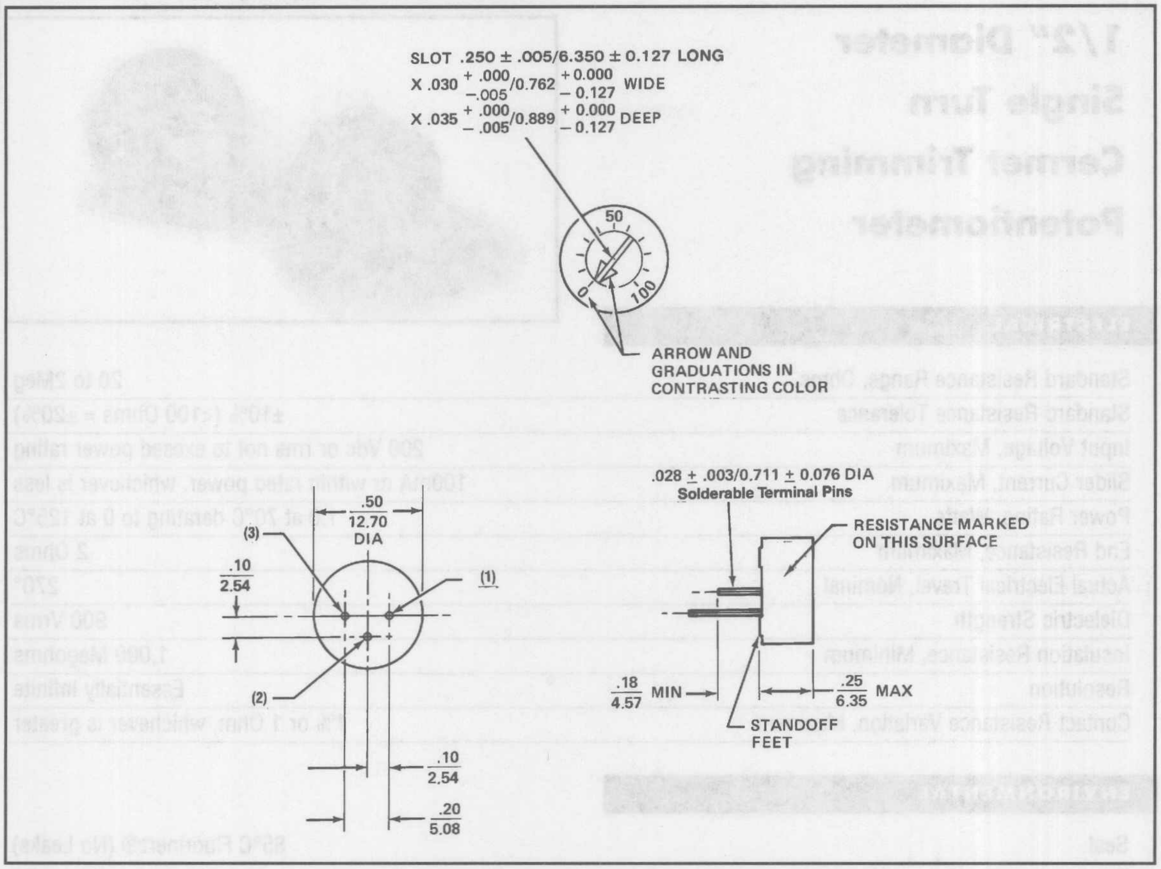
Mechanical Stops	24 oz.-in.
Stop Strength	1.5 lb.-in. (0.169 N-m)
Torque, Starting Maximum	5 oz.-in. (0.035 N-m)
Weight, Nominal	.052 oz. (1.5 grams)

Fluorinert® is a registered trademark of 3M Company.
Specifications subject to change without notice.

STANDARD RESISTANCE VALUES, OHMS

20	200	2K	20K	100K	500K
50	500	5K	25K	200K	1Meg
100	1K	10K	50K	250K	2Meg

TOP ADJUSTMENT



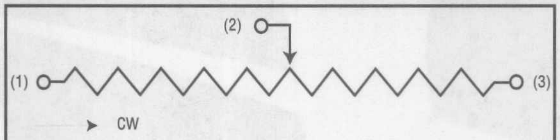
ORDERING INFORMATION

Standard:

93 P R 10K

- Model Series — 93
- Pin Style — P
- Resistance Prefix — R
- Resistance Value — 10K

CIRCUIT DIAGRAM



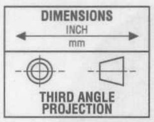
PACKAGING

Standard: Plastic Bags
Capacity = 50 Units

NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

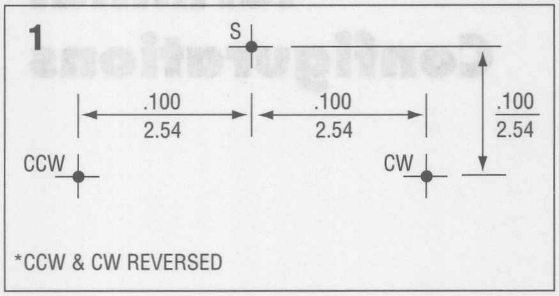
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



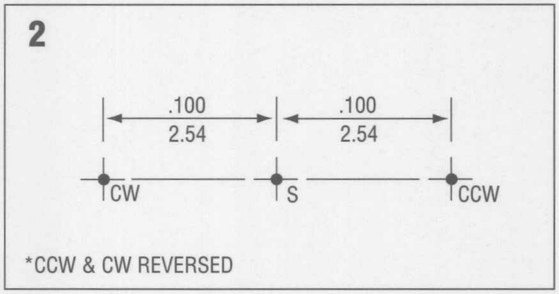
Terminal Configurations

1

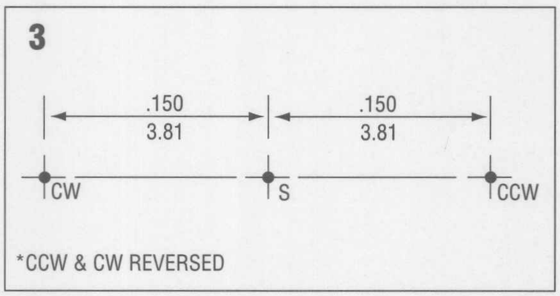
BI technologies CORPORATION



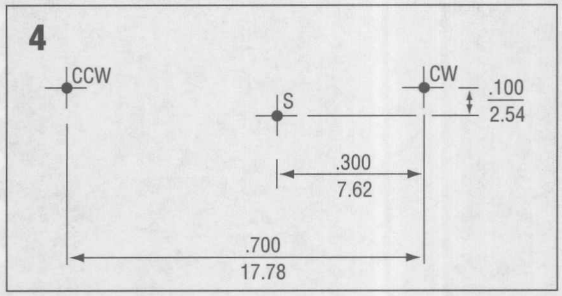
82PA, 62M, 91B*, 82M, 91T, 91X*, 72P*, 72X, 93P*, 66P*, 67P*, 67Y, 67Z, 68P*, 64W, 64X, 25P*, 25S, 25RS*, 25X, 25RX*, 64P, 72RX*



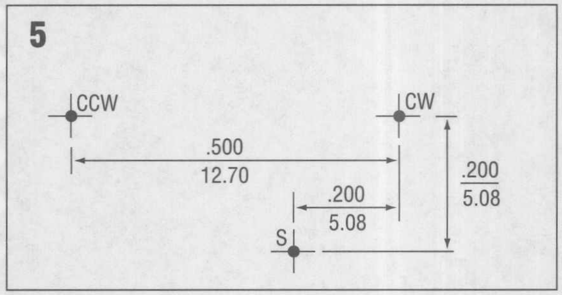
91A*, 91W*, 72PL, 72XL, 66W, 66X, 67W, 67X, 68W, 68X, 24U, 64Y, 64Z, 72RXL*, 72RW*, 82W, 25U*, 25V, 25RV*



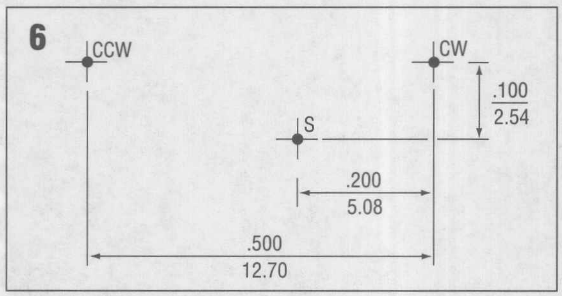
72PX, 72XW, 72RPX*, 72RXW*



89X, 89XH, 78P

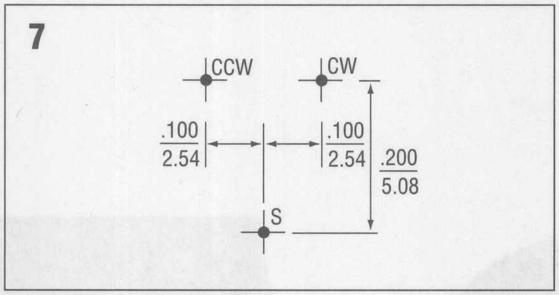


89W, 89WH



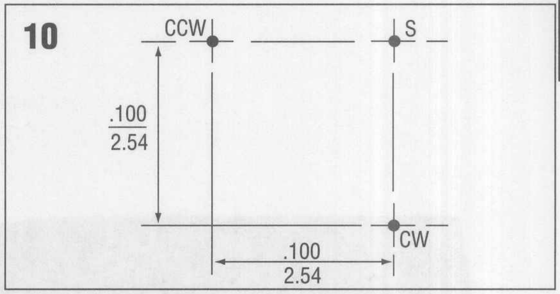
89P, 89PH, 90P

7



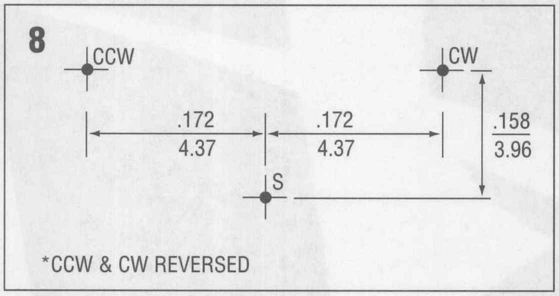
72PM

10



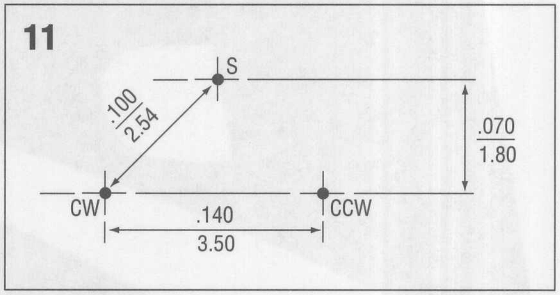
25W, 62P, 62PF, 82P, 82PF

8



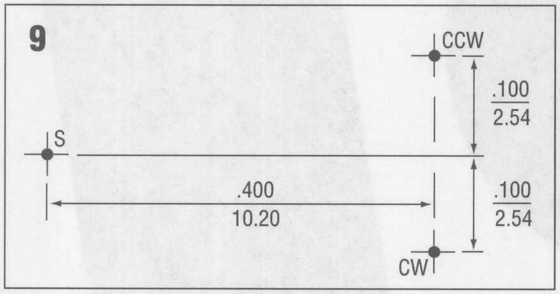
91V, 91C

11



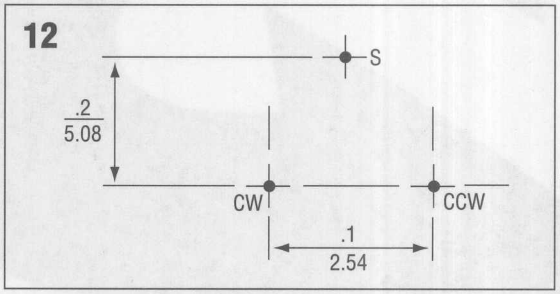
24W, 24S

9



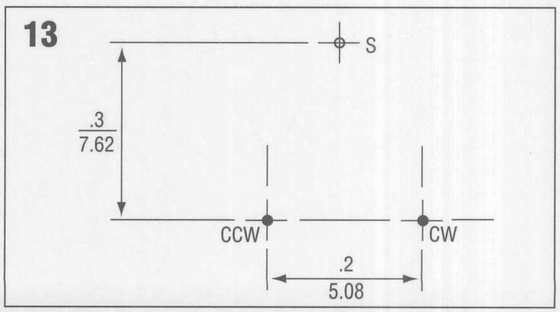
91E

12



23C

13



62B

Application Notes
Trimming Potentiometers

1

TRIMMING POTENTIOMETERS

The material in this section is intended to provide you with guidelines and thoughts to consider during the selection and application of BI Technologies line of trimming potentiometers. Proper component usage is important in achieving good overall performance, long life, and the lowest cost for your system. We have included in these notes additional information that may be helpful in preventing damage to trimmers that may occur from in-house or outside contract assembly and soldering processes. If you have questions that are not covered here, please don't hesitate to call and discuss your requirements with our application engineers.

TRIMMER STYLES, CONSTRUCTION, AND COMPONENT PARTS

There are three basic trimmer styles and their variations in this catalog. They are:

- Round single turn
- Square multiturn
- Rectangular multiturn

The basic components of each are the cermet resistance element, the wiper, and the rotor or slider and its drive mechanism that moves the wiper on the element. All must be designed and manufactured to operate together with high precision over a broad temperature range.

THE CERMET RESISTANCE ELEMENT

The cermet element is fundamentally responsible for the electrical performance of the trimmer. Key performance parameters such as the basic resistance value, temperature coefficient, voltage coefficient, resolution, and contact resistance variation (CRV) are directly related to the element construction.

THE WIPER OR MOVING CONTACT

The wiper is also a major contributor to good electrical performance. It must make reliable electrical contact with the surface of the cermet element. The contact resistance must be low and must not vary substantially as it is moved over the element surface. It must be accurately settable without backlash. Lastly, it must remain at its established set point without substantial dimensional shifting or corrosion under all trimmer operating conditions.

BI TECHNOLOGIES MATERIALS AND CONSTRUCTION

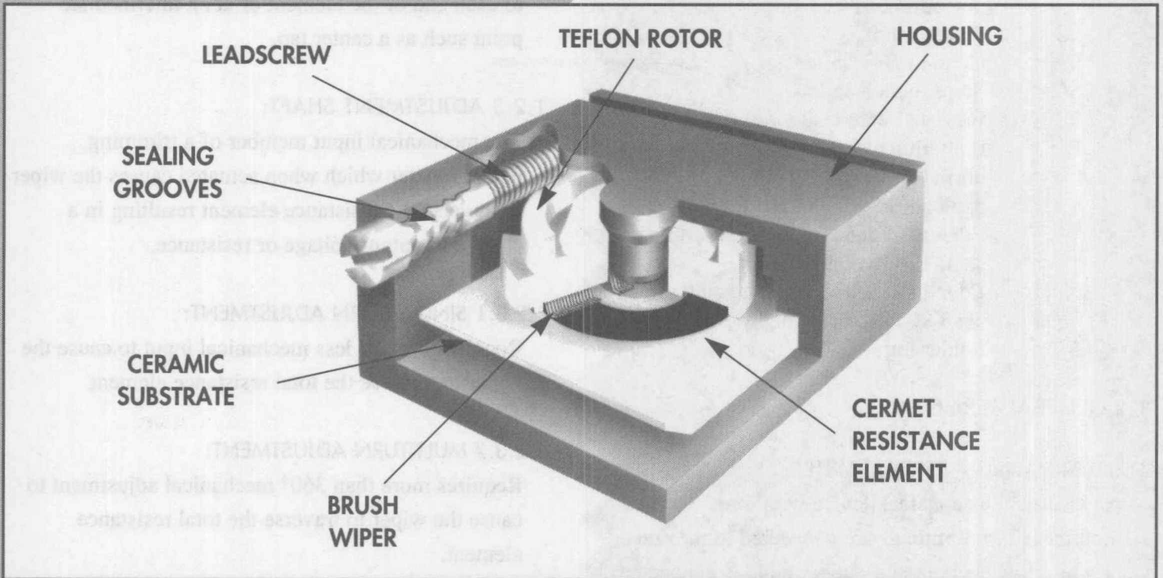
The combination of proprietary cermet element technology, precious metal brush contacts and swaged pin element connections used in BI trimmers permits the manufacture of precision, high quality trimmers that span the resistance range from 10 ohms to over 5 megohms. The small size and planar construction of these trimmers minimize stray circuit reactances and permit the trimmers to perform well in many high frequency applications.

Leadscrew
Precision brass leadscrew cuts its own grooves in the teflon rotor so that the operation of the rotor is free of backlash. Setability is excellent.

Sealing Grooves
Leadscrew has specially cut grooves to ensure a watertight seal.

Ceramic Substrate
High density substrate provides an excellent base for the element and is a good conductor of heat.

Cermet Element
BI's proprietary cermet element matches the materials in the wirebrush so that CRV is minimized and the high temperature setability is excellent.



Swaged Pins
BI's pin connections, which are swaged to the substrate, are free of solder and maintain high conductivity with time and temperature cycling.

1 TERMS AND DEFINITIONS

The terms and definitions used in this catalog have been edited from the Variable Resistive Components Institute (VRCI) data for trimming potentiometers.

VRCI publishes generally accepted terms, definitions, and test standards for trimming potentiometers, and for other variable resistive devices. If you would like additional information or definition on industry standards, please contact one of our application engineers.

1.1 LIST OF SYMBOLS

1.1.1 ELECTRICAL

E	-	Total applied voltage
e	-	Output voltage
e/E	-	Output ratio
ENR	-	Equivalent noise resistance
V_m	-	Minimum voltage
R_t	-	Total resistance
R_e	-	End resistance
R_m	-	Absolute minimum resistance
R_L	-	Load resistance
TC	-	Temperature coefficient of resistance
RTC	-	Resistance temperature characteristic
CRV	-	Contact resistance variation
CT	-	Center tap
SL	-	Wiper (slider)
P	-	Power handling capability in watts

1.1.2 MECHANICAL

CW	-	Clockwise rotation
CCW	-	Counterclockwise rotation
ST	-	Single turn trimming potentiometer

MT	-	Multiturn, screw actuated trimming potentiometer
SS	-	Stops, solid
C	-	Continuous rotation
SC	-	Stops, clutch action
L	-	Insulated wire lead terminals
P	-	Pin terminals, flat base mount normally for printed circuit application
W	-	Edge mounted terminals, adjustment shaft 180° from terminals
X	-	Edge mounted terminals, adjustment shaft 90° from terminals
S	-	Solder lug

1.2 GENERAL TERMS

1.2.1 TRIMMING POTENTIOMETER:

An electrical mechanical device with three terminals. Two terminals are connected to the ends of a resistive element and one terminal is connected to a movable conductive contact which slides over the element, thus allowing the input voltage to be divided as a function of the mechanical input. It can function as either a voltage divider or rheostat.

1.2.1.1 WIREWOUND TRIMMING POTENTIOMETER:

A trimming potentiometer characterized by a resistance element made up of turns of wire on which the wiper contacts only a small portion of each turn.

1.2.1.2 NON-WIREWOUND TRIMMING POTENTIOMETER:

A trimming potentiometer characterized by the continuous nature of the surface area of the resistance element to be contacted. Contact is maintained over a continuous, unbroken path. The resistance is achieved by using material compositions other than wire such as carbon, conductive plastic, metal film and cermet.

1.2.2 RESISTANCE ELEMENT:

A continuous, unbroken length of resistive material without joints, bonds or welds except at the junction of the element and the electrical terminals connected to each end of the element or at an intermediate point such as a center tap.

1.2.3 ADJUSTMENT SHAFT:

The mechanical input member of a trimming potentiometer which when actuated causes the wiper to traverse the resistance element resulting in a change in output voltage or resistance.

1.2.3.1 SINGLE TURN ADJUSTMENT:

Requires 360° or less mechanical input to cause the wiper to traverse the total resistance element.

1.2.3.2 MULTITURN ADJUSTMENT:

Requires more than 360° mechanical adjustment to cause the wiper to traverse the total resistance element.

1.2.4 TERMINAL:

An external member that provides electrical access to the resistance element and wiper.

1.2.4.1 LEADWIRE TYPE: (L)

Flexible insulated conductor.

1.2.4.2 PRINTED CIRCUIT TERMINAL:(P, W&X)

Rigid uninsulated electrical conductor so arranged, suitable for printed circuit board plug-in.

1.2.4.3 SOLDER LUG TERMINAL: (S)

Rigid uninsulated electrical conductor so arranged, suitable for external lead attachment.

1.2.5 WIPER: (SL)

The wiper is the member in contact with the resistive element that allows the output to be varied with the mechanical member adjustment.

1.2.6 STOP-CLUTCH: (SC)

A device which allows the wiper to idle at the ends of the resistive element without damage as the adjustment shaft continues to be actuated in the same direction.

1.2.7 STOP-SOLID: (SS)

A positive limit to mechanical and/or electrical adjustment.

1.2.8 STACKING:

The mounting of one trimming potentiometer adjacent to or on top of another utilizing the same mounting hardware.

1.2.9 THEORETICAL RESOLUTION:

(Wirewound only) The theoretical measurement of sensitivity to which the output ratio may be adjusted and is the reciprocal of the number of turns of wire in resistance winding expressed as a percentage.

N = Total number of resistance wire turns.

1/N X 100 = Theoretical resolution percent.

2 INPUT AND OUTPUT TERMS

2.1 INPUT TERMS

2.1.1 TOTAL APPLIED VOLTAGE: (e)

The total voltage applied between the designated input terminals.

2.2 OUTPUT TERMS

2.2.1 OUTPUT VOLTAGE: (e)

The voltage between the wiper terminal and the designated reference point. Unless otherwise specified, the designated reference point is the CCW terminal (See 3.1).

2.2.2 OUTPUT RATIO (OUTPUT VOLTAGE RATIO): (e/E)

The ratio of the output voltage to the designated input reference voltage. Unless otherwise specified, the reference voltage is the total applied voltage.

2.3 LOAD TERMS

2.3.1 LOAD RESISTANCE: (R_L)

An external resistance as seen by the Output Voltage (connected between the wiper terminal and the designated reference point).

3 ROTATION AND TRANSLATION

3.1 DIRECTION OF TRAVEL:

Clockwise (CW) or counterclockwise (CCW) rotation when viewing the adjustment shaft end of the potentiometer. The designation of terminals in the figure corresponds to the direction of wiper travel.

3.2 MECHANICAL TRAVEL

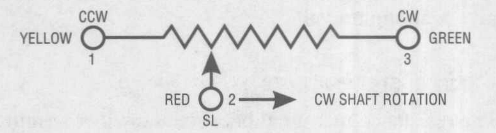


Figure 3.1 Circuit and Travel Diagram

3.2.1 MECHANICAL TRAVEL - SOLID STOPS: (SS)

The total travel of the adjustment shaft between integral stops. Continuity must be maintained throughout the travel.

3.2.2 MECHANICAL TRAVEL - CLUTCHING ACTION: (SC)

The total travel of the adjustment shaft between the points where clutch actuation begins. Continuity must be maintained throughout the travel and during clutch actuation.

3.2.3 MECHANICAL TRAVEL - CONTINUOUS ROTATION: (C)

The total travel of the adjustment shaft when the wiper movement is unrestricted at either end of the resistive element as the adjustment shaft continues to be actuated.

3.3 ADJUSTMENT TRAVEL (ELECTRICAL):

The total travel of the adjustment shaft between minimum and maximum output voltages.

3.4 CONTINUITY TRAVEL:

The total travel of the shaft over which electrical continuity is maintained between the wiper and the resistance element.

4 GENERAL ELECTRICAL CHARACTERISTICS

4.1 TOTAL RESISTANCE: (R_t)

The dc resistance between the input terminals with the wiper positioned to either end stop, or in dead band for continuous rotation potentiometers.

4.2 ABSOLUTE MINIMUM RESISTANCE: (R_m)

The resistance measured between the wiper terminal and each end terminal with the wiper positioned to give a minimum value.

4.3 END RESISTANCE: (R_e)

The resistance measured between the wiper terminal and an end terminal when the wiper is positioned at the corresponding end of mechanical travel. Absolute minimum resistance and end resistance are synonymous for continuous rotation trimmers.

4.4 TEMPERATURE COEFFICIENT OF RESISTANCE: (TC)

The unit change in resistance per degree celsius change from a reference temperature, expressed in parts per million per degree celsius as follows:

$$TC = \frac{R_2 - R_1}{R_1(T_2 - T_1)} \times 10^6$$

Where:

R_1 = Resistance at reference temperature in ohms

R_2 = Resistance at test temperature in ohms

T_1 = Reference temperature in degrees celsius

T_2 = Test temperature in degrees celsius

4.5 RESISTANCE-TEMPERATURE CHARACTERISTIC: (RTC)

The difference between the total resistance values measured at a reference temperature of 25°C and the specified test temperature expressed as a percent of the Total Resistance.

$$RTC = \frac{R_2 - R_1}{R_1} \times 100$$

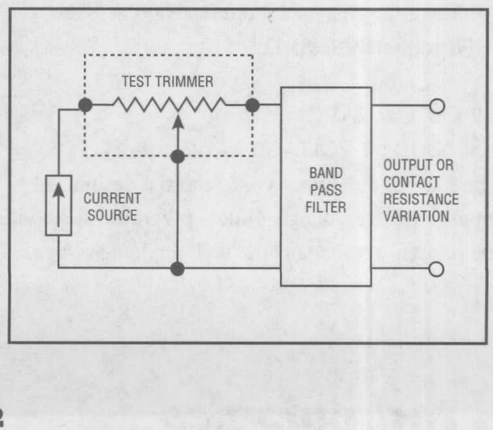
Where:

R_1 = Resistance at reference temperature (25°C) in ohms

R_2 = Resistance at the test temperature in ohms

4.6 CONTACT RESISTANCE VARIATION: (CRV)

The apparent resistance seen between the wiper and the resistance element when the wiper is energized with a specified current and moved over the adjustment travel in either direction at a constant speed. The output variations are measured over a specified frequency bandwidth, exclusive of the effects due to roll-on or roll-off of the terminations and is expressed in ohms or % of Rt.



4.7 EQUIVALENT NOISE RESISTANCE: (ENR)
(Wirewound only) Any spurious variation in the electrical output not present in the input, defined quantitatively in terms of an equivalent parasitic, transient resistance in ohms, appearing between the contact and the resistive element when the shaft is rotated or translated. The Equivalent Noise Resistance is defined independently of the resolution, functional characteristics and the total travel. The magnitude of the Equivalent Noise Resistance is the maximum departure from a specific reference line. The wiper of the potentiometer is required to be excited by a specific current and moved at a specific speed.

4.8 CONTINUITY:
Continuity is the maintenance of continuous electrical contact between the wiper and both end terminals of the resistive element.

4.9 SETTING STABILITY:
The amount of change in the output voltage, without readjustment, expressed as a percentage of the total applied voltage.

4.10 DIELECTRIC STRENGTH:
The ability to withstand the application of a specified potential of a given characteristic, between the terminals and all other external conducting member such as shaft, housing and mounting hardware without exceeding a specified leakage current value.

4.11 INSULATION RESISTANCE:
The resistance to a specified dc voltage impressed between the terminals and all other external conducting members such as shaft, housing and mounting hardware.

4.12 POWER RATING:
The maximum power that a trimming potentiometer can dissipate across the total resistive element under specified conditions while meeting specified performance requirements.

4.13 LIFE

4.13.1 ROTATIONAL LIFE:
The number of cycles obtainable under specific operating conditions while remaining within specified allowable degradation. A cycle is defined as one complete traversal of the wiper over the resistive element in both directions.

4.13.2 LOAD LIFE:
The number of hours at which a device may dissipate rated power under specified operating conditions while remaining within specified allowable degradations.

4.14 ADJUSTABILITY:
Defines the precision with which the output of a device can be set to the desired value.

4.14.1 ADJUSTABILITY
(OUTPUT RESISTANCE):
The precision with which the output resistance of a device can be set to the desired value.

4.14.2 ADJUSTABILITY
(OUTPUT VOLTAGE RATIO):
The precision with which the output voltage ratio of a device can be set to the desired value.

5 GENERAL MECHANICAL CHARACTERISTICS

5.1 TORQUE

5.1.1 STARTING (OPERATING) TORQUE:
The maximum moment in the clockwise and counterclockwise directions required to initiate shaft adjustment anywhere in the mechanical travel.

5.1.2 STOP TORQUE:

The maximum static moment that can be applied to adjustment shaft at each mechanical stop for a specified period of time without loss of continuity or mechanical damage affecting operational characteristics.

5.2 SOLDERABILITY:

The ability of the terminals to accept a uniform coating of solder under specified conditions.

5.3 WELDABILITY:

The ability of materials to be welded together under specified conditions.

5.4 TERMINAL STRENGTH:

The ability of the terminals to withstand specified mechanical stresses without sustaining damage that would affect utility of the terminals or operation of the trimming potentiometer.

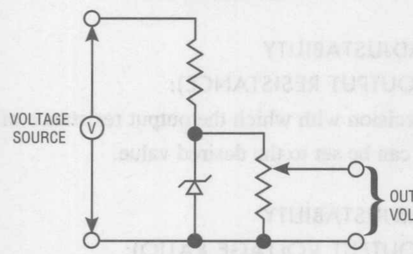
5.5 IMMERSION SEALED:

The ability of the unit to withstand submersion in acceptable cleaning solutions used in normal soldering processes without performance degradation under specific environmental conditions.

APPLICATION BASICS

A trimmer is generally used in an electrical or electronic circuit for the purpose of providing minor adjustments or calibrations. This implies that the trimmer is not used in the regular operation of the circuit, but would be required to make initial and periodic adjustments to compensate for circuit variables. This implies that the trimmer must be able to remain at its setting for long periods of time without variation in setting or contact resistance.

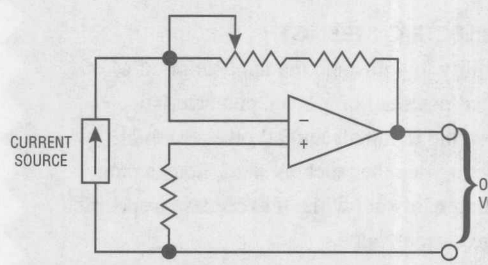
VOLTAGE ADJUSTMENT



Wiper current small due to high load impedance

Potentiometer Configuration

CURRENT ADJUSTMENT



Wiper current is large. Most of the current flows through the wiper.

Rheostat Configuration

A trimmer can be used as potentiometer or rheostat. A potentiometer is a three terminal device typically used to vary voltage. In potentiometric configurations, the wiper terminal is lightly loaded so that wiper current is generally small.

A rheostat is a two terminal device typically used to control current. Wiper current is generally larger in rheostat circuits.

I. Types of Applications

The majority of applications for trimmers occur in electronic circuits.

Typical uses are in the following devices:

A. Amplifiers
B. Timing circuits
C. Voltage and current regulators
D. Voltage and frequency converters

II. Selection Criteria

The initial considerations for trimmer type selection are:

A. Resolution of adjustment
B. Setability and time to set
C. Physical and environmental conditions
D. Stability of setting required
E. Circuit packaging requirements

A. Resolution of Adjustment

1. Multiturns

- Multiturns provide better resolution than single turns. Models with a longer element exhibit better resolution than those with a short element. Typical multiturn shaft revolutions range from 15 to 20 turns for end to end travel.
- The contact design and stability are important considerations in achieving high resolution. The contact area must be small and the contact must move smoothly in order to provide high resolution. A noisy contact will make accurate setting very difficult.
- All BI trimmers utilize smooth cermet materials, precious metal wire brush contacts and backlash-free wiper designs that ensure high resolution setability.
- Reference BI multiturn models:
  Square multiturns - 44, 64, 66, 67, 68
  Rectangular multiturns 78, 89

2. Single Turns

- Single turn resolution for models with a longer cermet element (larger diameter) is quite respectable. This is especially true with BI wire brush contacts and smooth cermet films.
- Reference BI single turn models:
  Small diameter - 24, 25, 62, 82
  Larger diameter - 72, 91, 93

3. Surface Mount Models

- Single turn - 21, 23, 83
- Multiturn - 44, 84

Call for application assistance if high resolution is critical in your application.

B. Setability and Time to Set

The enemies of setability are poor resolution, mechanical backlash and high CRV. BI has addressed these problems in the design of trimmer models. BI's smooth cermet materials, precious metal split brush contacts and teflon rotors work together to provide outstanding setability.

"Time to set" tests show the following:

Setting Attributes	Single Turn	Multiturn
High accuracy		Best
Fastest to high accuracy		Best
Fastest to approximate setting	Best	

C. Physical and Environmental Issues

1. Physical considerations in trimmer selection

- Case style desired
- Top or side adjust
- Pin style required
- Mechanical support required
- Board height requirements

2. Assembly process considerations
   BI offers a variety of trimmer models that are sealed to help protect against moisture and board washing processes.
   •Open vs. Sealed
   • Max time/temperature exposure
3. Environmental operating considerations
   • Operating temperature range
   • Resistance temperature coefficient
   • Vibration and shock tolerance
4. Human operating conditions
   When you complete your design, be careful to consider the tortures that clever human beings with a screwdriver in hand can impose on trimmers. For example, while a trimmer configuration mounted on edge might be a board space saver, a trimmer that mounts flat on the board may be more resistant to abuse by a heavy handed technician making adjustments through a hole in the chassis.

If you have questions about your options, call BI application engineers. We will help.

D. Stability of Setting

It is highly desirable that once the trimmer has been set, it should remain at that setting independent of time, operating temperature changes, vibration, shock and humidity. This property of stability is largely a factor of the compatibility of the materials at the moving contact interface and the thermal matching of the elements of the trimmer structure.

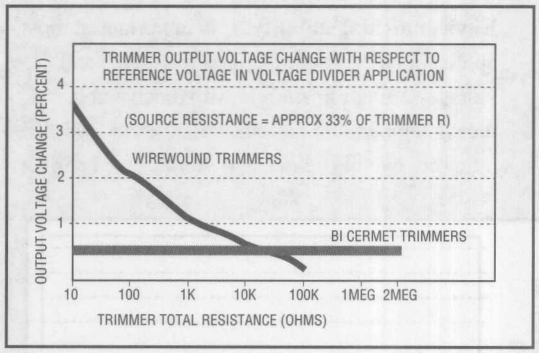
BI uses noble metals in both the wire brush contact and the cermet element. These materials are relatively soft, highly compatible and provide an excellent, low resistance, non-corroding interface. The contact drive structure and materials are chosen for their stability and compatibility. The high contact forces utilized at the brush/element interface reduce susceptibility to shock and vibration. The circuit designer can contribute significantly to short term operating and long term stability by mounting the trimmer away from high thermal gradients, hot spots and sources of excessive vibration.

E. Circuit Packaging

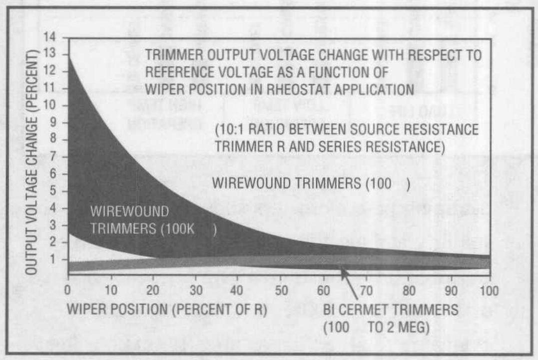
BI manufactures trimmers in a variety of package styles and sizes. The chances are excellent that stock models are locally available that will fit your requirements. Models include both pin style and surface mount single and multiturn configurations. Special electrical and mechanical features are available for specific customer applications. Call your local representative or the factory direct for information on special packaging.

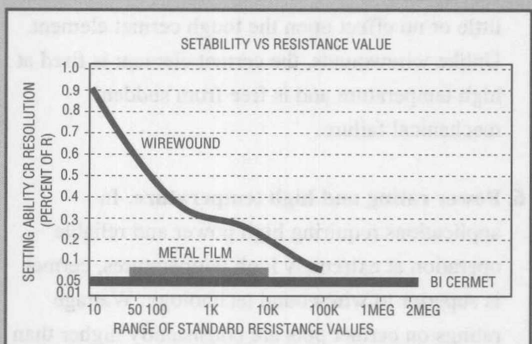
DESIGN CONSIDERATIONS AND THE CERMET ADVANTAGE

CHARACTERISTICS	WIREWOUND	NON WIREWOUND TRIMMERS			
		Cermet	Hot-Mold Carbon	Carbon Film	Thin-Metal Film
Setting Ability	Poor to Good	Excellent	Excellent	Excellent	Excellent
Resistance Range	Low to Medium	Low thru High	Medium to High	Medium to High	Low to Medium
Power Rating	Medium	High	Low	Low	Medium
Temp Coefficient	Lowest	Low to Med	High	High	Low
Environmental Stability					
High Temperature	Good to Exc.	Excellent	Poor	Fair	Excellent
Load Life	Good to Exc.	Excellent	Fair	Fair	Excellent
Humidity	Good to Exc.	Excellent	Poor	Poor	Excellent
Rotational Life	Good	Excellent	Good	Good	Fair
Rheostat Usage	Good	Fair to Good	Poor	Poor	Fair
AC Usage	Fair	Excellent	Excellent	Excellent	Excellent

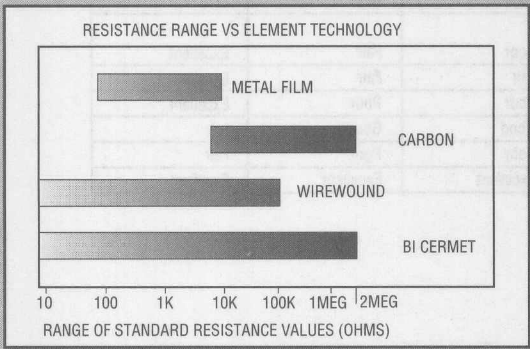


1. **Essentially infinite resolution.** Proprietary cermet BI film materials and wire brush technology produce a cermet trimmer that provides essentially infinite resolution. Wirewound trimmers are limited in resolution because each wire turn appears as a definite "step" during adjustment. As a result, a wirewound's best setting ability is in the order of 0.17%, and this is possible only at resistance values of 50K and 100K ohms where very fine fragile wire is used. The cermet element provides a setting ability as precise as ±0.01%.

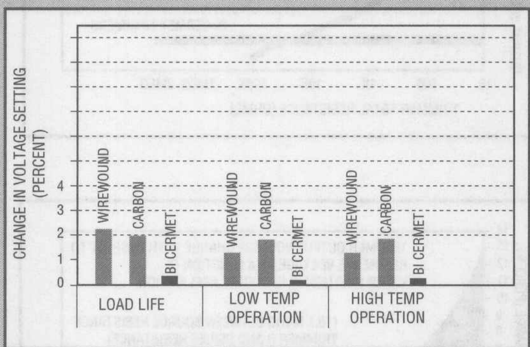




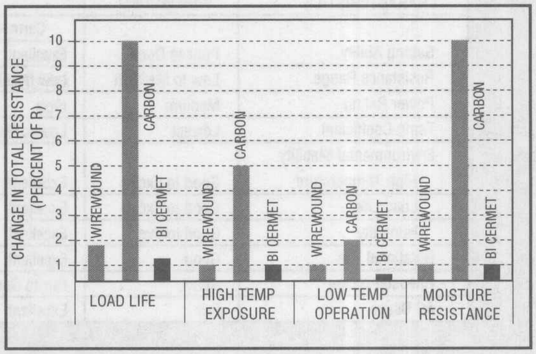
2. **Wide resistance range.** BI cermet trimmer technology covers applications from 10 ohms thru 2 megohms. This can simplify and reduce design, testing and stocking costs.



3. **Environmental stability.** It is important in most applications that both the total resistance and voltage setting remain relatively unchanged during temperature extremes, long-term load life, humidity cycling, shock and vibration. BI cermet



trimming potentiometers show superior resistance stability and excellent voltage setting stability. Certified test reports covering the resistance range of 100 ohms to 500K show that the average change in total resistance after 1,000 hour load life tests is 0.3% with a maximum observed change of 1.25%.

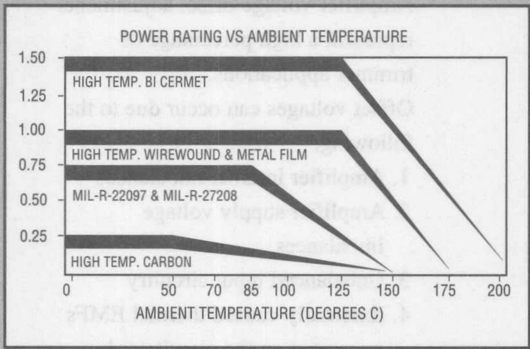


4. **Lower costs.** Cermet potentiometers not only perform well, but typically cost less. BI cermet trimmers, for example, are generally priced lower than wirewound and metal film competitors. Cermet prices are also generally uniform across the resistance range, whereas other trimmer prices may vary as much as 100 percent, depending upon the resistance value desired.

5. **Longer, trouble-free life.** The useful operational life of a cermet trimmer far exceeds that of wirewounds, metal film and carbon units. The cermet element has substantial thickness, and its hard surface is resistant to abrasion. Moisture has little or no effect upon the tough cermet element. Unlike wirewounds, the cermet element is fired at high temperature and is free from sudden mechanical failure.

6. **Power rating and high temperature.** In applications requiring high power and reliable operation at extremely high temperatures, cermet is superior to wirewound technology. Wattage ratings on cermet pots are consistently higher than comparable wirewounds, and the cermet units can withstand power surges several times their rated wattage. Wirewounds and thin metal film potentiometers are extremely susceptible to

failure when operated at temperatures or power levels above their ratings. Power overloads can burn out wire, whereas cermet units operate satisfactorily above rated power limits for substantial periods of time.



7. A.C. performance. Cermet potentiometers perform at frequencies up to 200 megahertz with minimal phase shift. In wirewounds, there is high phase shift in frequencies over 400 Hz, due to capacitance from resistance wire to the core and inductive effects of the coil.

8. Reliability. In BI's reliability and quality control program, every step and process during manufacture is closely controlled to assure conformance to stringent BI standards. These standards are designed to assure maximum reliability in the product's end use.

9. Tempco. The temperature performance of a trimmer is based upon more than the tempco of the resistance element. In evaluating comparable wirewound and cermet trimmers, the effect of tempco is found to be considerably less in cermet when other effects such as resolution and setting stability are included. To consider wire tempco alone is like measuring an automobile's performance strictly on the basis of the engine's horsepower rating. In circuit applications, there is more to consider, since the amount of voltage or resistance shift is the product of resolution and wiper stability as well as tempco. In practical applications, cermet stability is superior to wirewounds. If you add in environmental effects of vibration and shock, cermet wins by an even wider margin. The charts illustrate cermet vs wirewound stability in both voltage divider and rheostat applications.

SOME THOUGHTS FOR THE CIRCUIT DESIGNER

Rotation Conventions

In general, it is preferable to connect the trimmer so that clockwise rotation:

1. Increases the attribute quantity
2. Moves the position "up"
3. Moves the position "right"

There are exceptions. The important thought is to make the adjustment as intuitive as possible.

Maximum Ratings

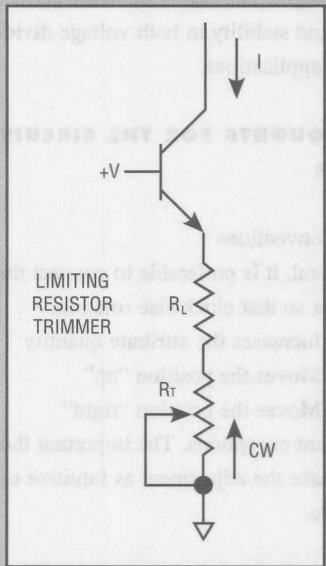
Pay attention to maximum voltage, current and power ratings in both normal and non-operating conditions. Non-operating conditions, such as warm up, device failure and misadjustment, may be easily overlooked in the product design and testing cycles. Take appropriate steps to establish adjustment limits through hardware.

Linear Circuit Applications

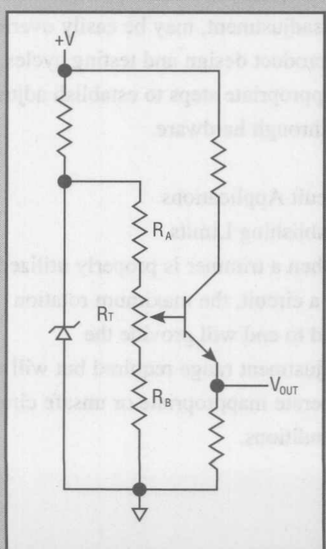
A. Establishing Limits

When a trimmer is properly utilized in a circuit, the maximum rotation end to end will provide the adjustment range required but will not operate inappropriate or unsafe circuit conditions.

The rheostat R_T in the circuit shown below will become a short circuit when rotated fully counterclockwise. Limiting resistor R_L is required to limit both trimmer and transistor currents to safe levels.



The potentiometer in the circuit shown below adjusts the output voltage over a specific range as limited by the values of R_A and R_B.



Define adjustment limits carefully and establish them with appropriate circuitry.

B. Dealing With Amplifier Offset Voltage

Amplifier voltage offset adjustments represent a high percentage of trimmer applications.

Offset voltages can occur due to the following:

1. Amplifier internal imbalances
2. Amplifier supply voltage imbalances
3. Unbalanced input circuitry
4. Externally-caused thermal EMFs generated on the circuit card

All of the above can change with time, ambient temperature and varying input circuit conditions.

There are two general types of voltage offset solutions:

1. Take steps to avoid thermally generated offset problems by minimizing board hot spots and by locating sensitive circuits away from thermal gradients.
   Balance voltages and impedances where possible.
2. Provide a means of zeroing the offset voltages. Two methods are shown below:
   a. For amplifiers with offset trim terminals, the circuit in figure 1 can provide compensation that can be appropriately scaled by the size of R_1 and R_2. This method becomes inappropriate when the trimmer wiper current becomes small enough to risk dry circuit conditions.

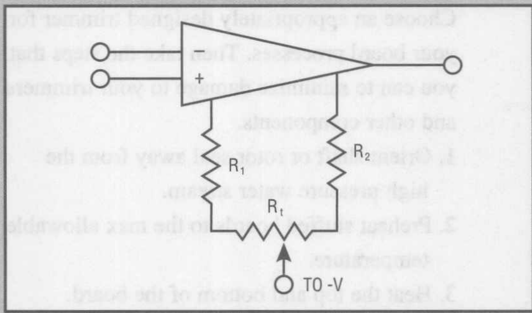


FIGURE 1.

b. When the circuit in Figure 1 becomes inappropriate, the circuit shown in Figure 2 can be used. Scale R_1, R_2, R_T, R_A, and R_B as required. This circuit can also be adapted for use in a potentiometric amplifier circuit configuration if required.

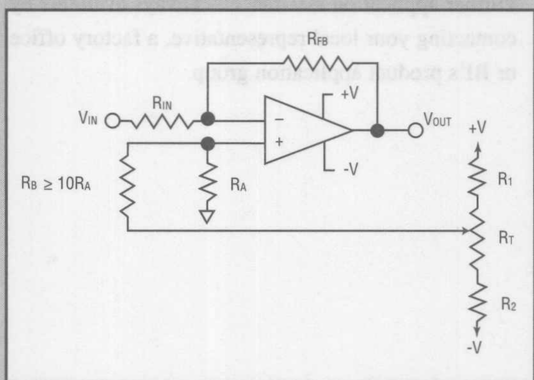
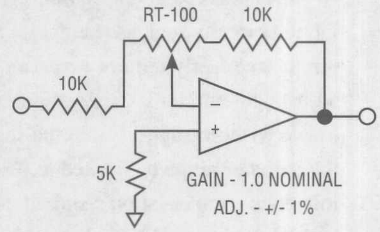


FIGURE 2.

C. Correctly Using the Trimmer to Avoid Dry Circuit Risk

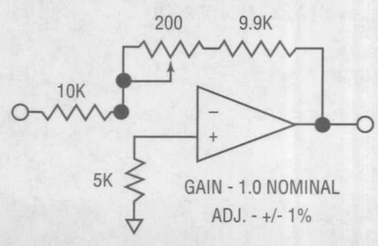
The end connections to BI cermet elements are made with a swaging process so that the resistance of the end connections remains small and constant for the life of the device. The connection between the moving contact and the element surface, however, is not gas tight and requires special consideration.

BI's precious metal brush contact provides a surface-conforming, non-oxidizing, high force connection that is highly superior to trimmers using non-precious metal wipers and films. In a few circuit applications such as the op amp gain control circuit below, the current through the wiper would be very low (nano or pico amps). This is not enough current to absolutely ensure a low resistance contact in the absence of contact motion.



POSSIBLE DRY CIRCUIT PROBLEMS

The circuit designer would be wise to consider an alternate circuit configuration to avoid the dry circuit problems that might arise. This is especially important in circuits that are adjusted and then forgotten for long periods. In the example shown below, the amplifier current will flow through the wiper contact to minimize the possibility of a high resistance connection. This circuit is also superior to the one above in that an open wiper will only cause a small shift in gain versus amplifier lockup in the circuit above.



ELIMINATES DRY CIRCUIT RISK

D. Digital Circuits Also Need Trimmers

The same general analog circuit considerations apply to digital circuits, although you may not have to worry as much about dry circuit conditions in digital applications.

1. Think about rotation conventions
2. Pay attention to maximum ratings
3. Limit unnecessary adjustment range with additional resistors
4. Tie the unused end of the trimmer to the wiper in rheostat configurations

Digital circuits such as oscillators and timers frequently require very precise adjustment and long term stability. In these cases, wisdom suggests that the selection of the trimmer range be limited to just the tolerance compensation required and that a multiturn trimmer be used to achieve the best resolution and stability possible.

E. Surviving the Circuit Board Manufacturing Process

The printed circuit board assembly and cleaning processes are likely to subject your trimmers to the most severe ambient conditions that the trimmer will see in its lifetime. For example:

Parameter	Typical	Some Processes
Positive Temperature Shock (°C)	70	125
Negative Temperature Shock (°C)	25	70
Max Temperature (°C)	150	180
Time above 125°C (sec.)	20	75
Number of Temperature Cycles	5	10-12

Choose an appropriately designed trimmer for your board processes. Then take the steps that you can to minimize damage to your trimmers and other components.

1. Orient shaft or rotor seal away from the high pressure water stream.
2. Preheat stuffed boards to the max allowable temperature.
3. Heat the top and bottom of the board.
4. Reduce the time in the solder.
5. Lengthen the time between solder and wash cycles.
6. Cool the boards prior to entering the wash cycle.
7. Minimize the temperature difference between wash and rinse cycles.
8. Use heated air for air knives.

Further application assistance is always available by contacting your local representative, a factory office, or BI's product application group.

Precision Potentiometers & Position Sensors

2

BI technologies
CORPORATION

MULTI-TURN PRECISION POTENTIOMETERS

MODEL NUMBER	NUMBER OF TURNS	HOUSING (OUTSIDE DIAMETER)	ELEMENT*	RESISTOR RANGE (OHMS)	STANDARD RESISTANCE TOLERANCE	STANDARD LINEARITY	MOUNTING STYLE
7381	3	7/8"	WW	100 to 30K	±5%	±0.50%	Bushing
7383	3	7/8"	WW	100 to 30K	±5%	±0.50%	Servo
7386	3	7/8"	WW	100 to 30K	±5%	±0.50%	Bushing
9301	3	1-13/16"	WW	30 to 90K	±5%	±0.25%	Bushing
9303	3	1-13/16"	WW	30 to 90K	±5%	±0.25%	Servo
C	3	1-13/16"	WW, HYB	5 to 194.7K	±3% (<100Ω=±5%)	±0.50%	Bushing
7481	5	7/8"	WW	100 to 50K	±5%	±0.30%	Bushing
7483	5	7/8"	WW	100 to 50K	±5%	±0.30%	Servo
7486	5	7/8"	WW	100 to 50K	±5%	±0.30%	Bushing
7216	10	7/8"	WW, HYB	10 to 125K	±3%	±0.25%	Bushing
7221	10	7/8"	WW, HYB	10 to 125K	±3%	±0.25%	Bushing
7223	10	7/8"	WW, HYB	10 to 125K	±3%	±0.25%	Servo
7246	10	7/8"	WW, HYB	10 to 125K	±5%	±0.25%	Bushing
7274	10	7/8"	WW	100 to 100K	±5%	±0.25%	Bushing
7276	10	7/8"	WW	100 to 100K	±5%	±0.25%	Bushing
7281	10	7/8"	WW	100 to 100K	±5%	±0.25%	Bushing
7283	10	7/8"	WW	100 to 100K	±5%	±0.25%	Servo
7284	10	7/8"	WW	100 to 100K	±5%	±0.25%	Bushing
7286	10	7/8"	WW	100 to 100K	±5%	±0.25%	Bushing
8136	10	7/8"	HYB	1K to 100K	±10%	±0.25%	Bushing
8141	10	7/8"	HYB	1K to 100K	±10%	±0.25%	Bushing
8143	10	7/8"	HYB	1K to 100K	±10%	±0.25%	Servo
8146	10	7/8"	HYB	1K to 100K	±10%	±0.25%	Bushing
7601	10	1-13/16"	WW	1K to 650K	±5%	±0.15%	Bushing
7603	10	1-13/16"	WW	1K to 650K	±5%	±0.15%	Servo
A	10	1-13/16"	WW	10 to 500K	±3% (<100Ω=±5%)	±0.25% (<300Ω=±0.50%)	Bushing
B	15	3-5/16"	WW	40 to 2 Meg	±5%	±0.50%	Bushing
BSP	15	3-5/16"	WW	40 to 2 Meg	±5%	±0.50%	Servo
D	25	3-5/16"	WW	60 to 3.3 Meg	±5%	±0.50%	Bushing
DSP	25	3-5/16"	WW	60 to 3.3 Meg	±5%	±0.50%	Servo
E	40	3-5/16"	WW	125 to 5.3 Meg	±5%	±0.50%	Bushing
ESP	40	3-5/16"	WW	125 to 5.3 Meg	±5%	±0.50%	Servo

* CP = Conductive Plastic
WW = Wirewound
HYB = Hybrid

SINGLE TURN PRECISION POTENTIOMETERS

MODEL NUMBER	HOUSING (OUTSIDE DIAMETER)	ELEMENT*	RESISTOR RANGE (OHMS)	STANDARD RESISTANCE TOLERANCE	STANDARD LINEARITY	MOUNTING STYLE
5101	7/8"	WW	200 to 15K	±5%	±0.5%	Bushing
5103	7/8"	WW	200 to 15K	±5%	±0.5%	Servo
6163	7/8"	CP	1K to 100K	±10%	±1.0%	Servo
6173	7/8"	CP	1K to 100K	±10%	±0.5%	Servo
6181	7/8"	CP	1K to 100K	±10%	±1.0%	Bushing
6186	7/8"	CP	1K to 100K	±10%	±1.0%	Bushing
6187	7/8"	CP	1K to 100K	±10%	±1.0%	Bushing
6273	1-1/16"	CP	1K to 900K	±10%	±0.5%	Servo
3371	1-5/16"	CP	1K to 900K	±10%	±0.5%	Bushing
3381	1-5/16"	CP	1K to 300K	±10%	±0.5%	Bushing
5311	1-5/16"	WW	10 to 44.6K	±3% (<40Ω=±5%)	±0.5% (<250Ω=±1.0%)	Bushing
6371	1-5/16"	CP	1K to 300K	±10%	±0.5%	Bushing
6373	1-5/16"	CP	1K to 300K	±10%	±0.5%	Servo
5401	1-7/16"	WW	25 to 50K	±5%	±0.5% (<100Ω=±1.0%)	Bushing
5403	1-7/16"	WW	25 to 50K	±5%	±0.5% (<100Ω=±1.0%)	Servo
5611	2"	WW	15 to 80K	±5%	±0.5% (<50Ω=±1.0%)	Bushing
5613	2"	WW	15 to 80K	±5%	±0.5% (<50Ω=±1.0%)	Servo
6671	2"	CP	1K to 300K	±10%	±0.25%	Bushing
6673	2"	CP	1K to 300K	±10%	±0.25%	Servo
5711	3"	WW	25 to 145K	±5%	±0.5%	Bushing
5713	3"	WW	25 to 145K	±5%	±0.5%	Servo

* CP = Conductive Plastic
WW = Wirewound
HYB = Hybrid

MODEL A

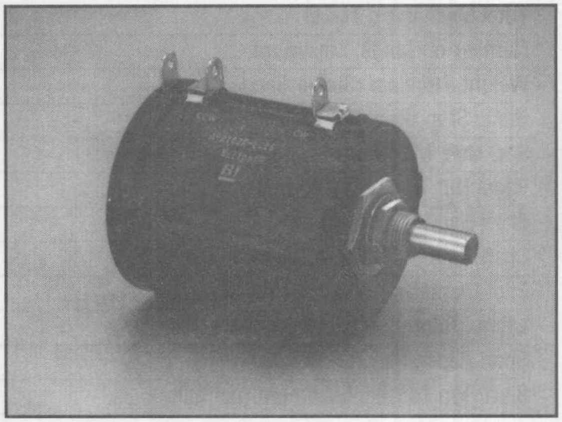
1-13/16″ Diameter

10-Turn

Wirewound

Precision Potentiometer

Distributor Item



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ELECTRICAL

Resistance Range, Ohms	10 to 500K
Standard Resistance Tolerance	< 100 Ohms = ±5%, ≥ 100 Ohms = ±3%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	< 300 Ohms = ±0.50%, ≥ 300 Ohms = ±0.25%
Minimum Practical Independent Linearity	±0.15%, ≤ 20 Ohms ±0.10%, < 100 Ohms ±0.075%, < 300 Ohms ±0.05%, ≥ 300 Ohms
Power Rating, Watts	5.0 at 40°C derating to 0 at 85°C
Input Voltage, Maximum	1,000V dc not to exceed power rating
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	500 Ohms: RT ≤ 2613.7 Ohms 250 Ohms: RT > 2613.7 Ohms
Actual Electrical Travel	3600° + 4° − 0°
Tap Tolerance	≤ 20 Ohms = ±3°, < 100 Ohms = ±2° < 300 Ohms = ±1.5°, ≥ 300 Ohms = ±1°
End Voltage, Maximum (% of input voltage)	10 Ohms = 3%, 25 Ohms = 1.2% 50 Ohms = 0.6%, ≥100 Ohms = 0.25%

This model available in a hybrid version – contact factory for details.

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	Static: −65°C to +85°C Dynamic: −40°C to +85°C
Temperature Cycling	5 cycles, −65°C to +85°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	6 hours, 10 to 55 Hz (5% ΔRT, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 85°C (5% ΔR)
Rotational Load Life	2 mil. shaft rev. + 900 hrs. at rated wattage at 40°C (5% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	3600° + 4° – 0°
Number of Gangs, Maximum	3
Weight, Nominal (Single Gang)	4.4 oz.
Static Stop Strength	550 oz.-in.
Backlash, Maximum	1°
Panel Nut Tightening Torque, Maximum	25 lb.-in.
Shaft End Play, Maximum	.005"
Shaft Runout, T.I.R., Maximum	.0005"
Pilot Diameter Runout, T.I.R., Maximum	.002"
Lateral Runout, T.I.R., Maximum	.003"
Shaft Radial Play, Maximum	.003"
Start/Run Torque, Maximum (per gang)	3.0 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
10	0.082	+800 ppm/°C *
25	0.040	+800 ppm/°C *
50	0.031	+800 ppm/°C *
100	0.040	±20 ppm/°C
200	0.031	±20 ppm/°C
500	0.024	±20 ppm/°C
1K	0.021	±20 ppm/°C
2K	0.016	±20 ppm/°C
5K	0.014	+130 ppm/°C *
10K	0.011	+130 ppm/°C *
20K	0.009	+130 ppm/°C *
50K	0.007	+130 ppm/°C *
100K	0.006	±20 ppm/°C
200K	0.005	±20 ppm/°C
300K	0.005	±20 ppm/°C
500K	0.005	±20 ppm/°C

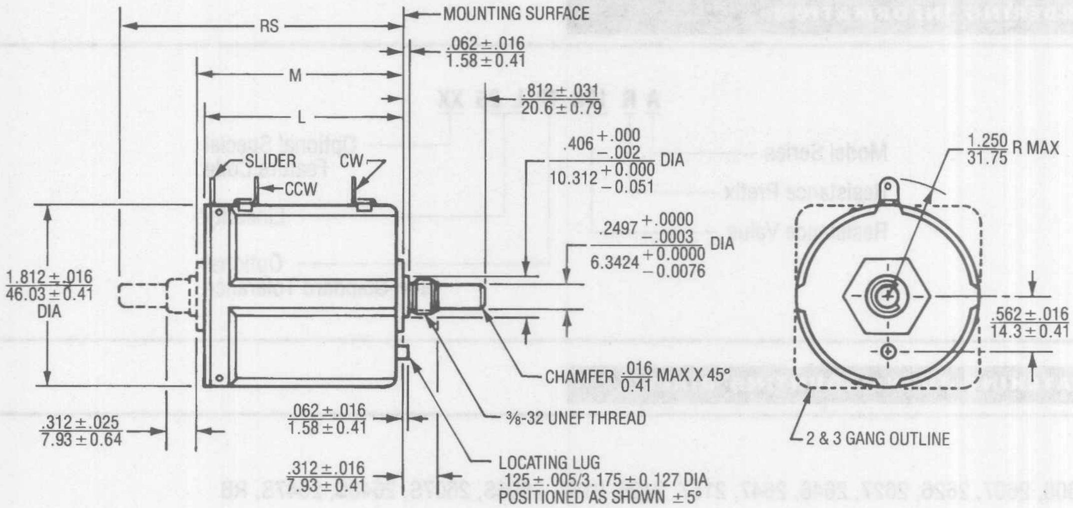
* Lower tempco available as a special model

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

OUTLINE DIMENSIONS

Dim. "L"	Dim. "M"	Dim. "RS"	No.of Gangs
2.016 / 51.21 MAX.	2.062±.031 / 52.38±0.79	2.875±.031 / 73.03±0.79	1
4.243 / 107.78 MAX.	4.205±.031 / 106.81±0.79	5.016±.031 / 127.41±0.79	2
6.143 / 156.04 MAX.	6.100±.031 / 154.94±0.79	6.906+.031 / 175.42±0.79	3



SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock	SL
Color Coded	CC
Additional Gangs	2G or 3G

ORDERING INFORMATION

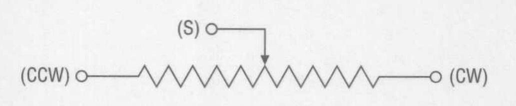
A R 10K T2 L.25 XX

- Model Series — A
- Resistance Prefix — R
- Resistance Value — 10K
- Optional Non-Standard Tolerance — T2
- Linearity — L.25
- Optional Special Feature Code — XX

MATCHING TURNS COUNTING DIALS

2606, 2607, 2626, 2627, 2646, 2647, 2157, 2126, 2167, 2606S, 2607S, 2646S, 2647S, RB

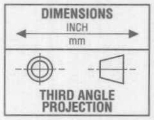
CIRCUIT DIAGRAM



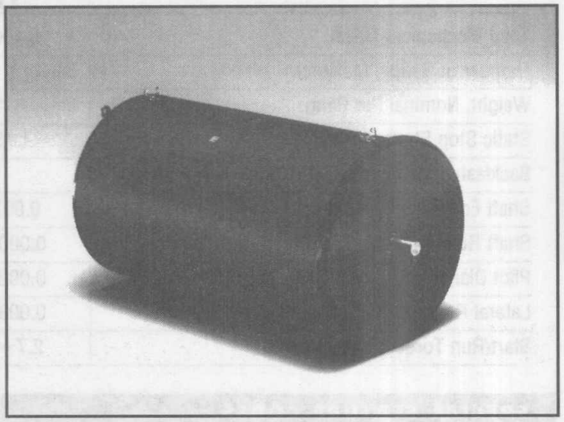
NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL SERIES
B, D & E
3-5/16" Diameter
Multi-Turn
Wirewound
Precision Potentiometer



2

ELECTRICAL	B/BSP	D/DSP	E/ESP
	15 TURN	25 TURN	40 TURN
Resistance Range, Ohms	40 to 2 Meg	60 to 3.3 Meg	125 to 5.3 Meg
Standard Resistance Tolerance	±5%	±5%	±5%
Minimum Practical Resistance Tolerance	±1%	±1%	±1%
Independent Linearity	±0.50%	±0.50%	±0.50%
Input Voltage, Maximum (Not to Exceed Power Rating)	1,000V dc	1,000V dc	1,000V dc
Power Rating, Watts (Derating to 0 at 85°C)	10 at 40°C	15 at 40°C	20 at 40°C
Dielectric Strength	1,000V rms	1,000V rms	1,000V rms
Insulation Resistance, Minimum	100 Megohms	100 Megohms	100 Megohms
Actual Electrical Travel, Nominal	5,400° +4° -0°	9,000° +4° -0°	14,400° +4° -0°
End Voltage, Maximum	<0.50% of Input Voltage	<0.50% of Input Voltage	<0.50% of Input Voltage
Minimum Practical Independent Linearity:			
<100 Ohms	±0.10%	±0.05%	±0.05%
100 Ohms to 999 Ohms	±0.05%	±0.05%	±0.05%
≥1K Ohms	±0.035%	±0.035%	±0.035%
Noise: 500 Ohms, Maximum, RT =	≤8K	≤13K	≤30K
250 Ohms, Maximum, RT =	>8K	>13K	>30K
Tap Tolerance: ±1.5°, RT =	<70 Ohms	<100 Ohms	<150 Ohms
±1.0°, RT =	≥70 Ohms	≥100 Ohms	≥150 Ohms
Temperature Coefficient: 800ppm/°C, RT =	40 Ohms to 265 Ohms	60 Ohms to 440 Ohms	125 Ohms to 700 Ohms
20ppm/°C, RT =	300 Ohms to 8K, >142K	500 Ohms to 13.5K, >230K	800 Ohms to 30K, >340K
130ppm/°C, RT =	8.6K to 128K	14K to 213K	34K to 340K

ENVIRONMENTAL (MIL-R-12934)	B/BSP	D/DSP	E/ESP
	15 TURN	25 TURN	40 TURN
Temperature Cycling, -65° to +85°C	5% ΔR	5% ΔR	5% ΔR
Low Temperature Exposure, 24 hrs. at -65°C	5% ΔR	5% ΔR	5% ΔR

Specifications subject to change without notice.

MECHANICAL	B/BSP 15 TURN	D/DSP 25 TURN	E/ESP 40 TURN
Total Mechanical Travel	5,400° +4° -0°	9,000° +4° -0°	14,400° +4° -0°
Number of Gangs, Maximum	3	1	1
Weight, Nominal Per Gang	13 oz.	17 oz.	21 oz.
Static Stop Strength	1.150 oz.-in.	730 oz.-in.	730 oz.-in.
Backlash, Maximum	0.2°	0.2°	0.2°
Shaft End Play, Maximum	0.007" / 0.005"	0.016" / 0.007"	0.016" / 0.007"
Shaft Runout, T.I.R., Maximum	0.0005" / 0.001"	0.002"	0.002"
Pilot Diameter Runout, T.I.R., Maximum	0.002" / 0.0015"	0.002"	0.002"
Lateral Runout, T.I.R., Maximum	0.003" / 0.0065"	0.003" / 0.004"	0.003" / 0.004"
Start/Run Torque, Maximum	2.7 / 2.0 oz.-in.	3.5 / 2.5 oz.-in.	3.5 / 2.5 oz.-in.

SPECIAL FEATURE CODES

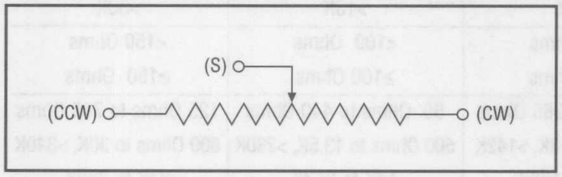
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS

ORDERING INFORMATION

B R 10K T1 L .5 XX

- Model Series
- Resistance Prefix
- Resistance Value
- Optional Non-Standard Tolerance
- Linearity
- Optional Special Feature Code

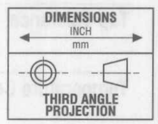
CIRCUIT DIAGRAM



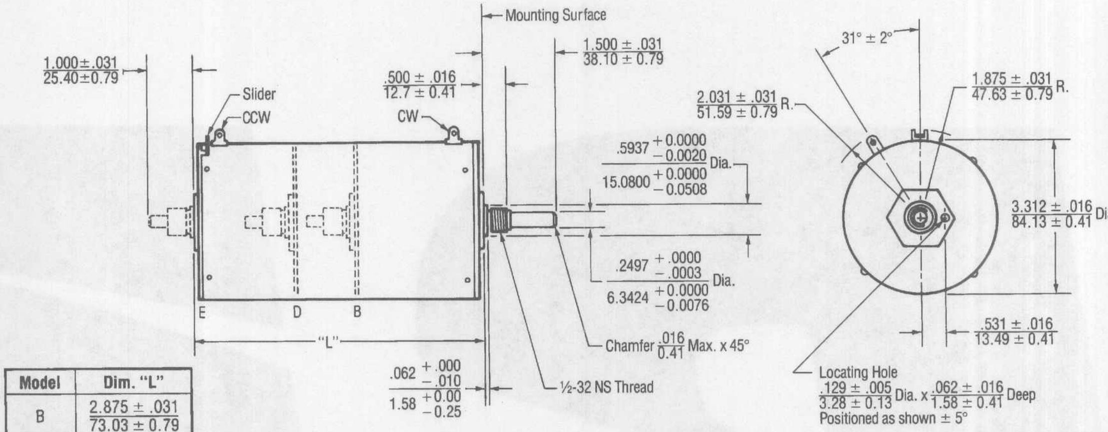
NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

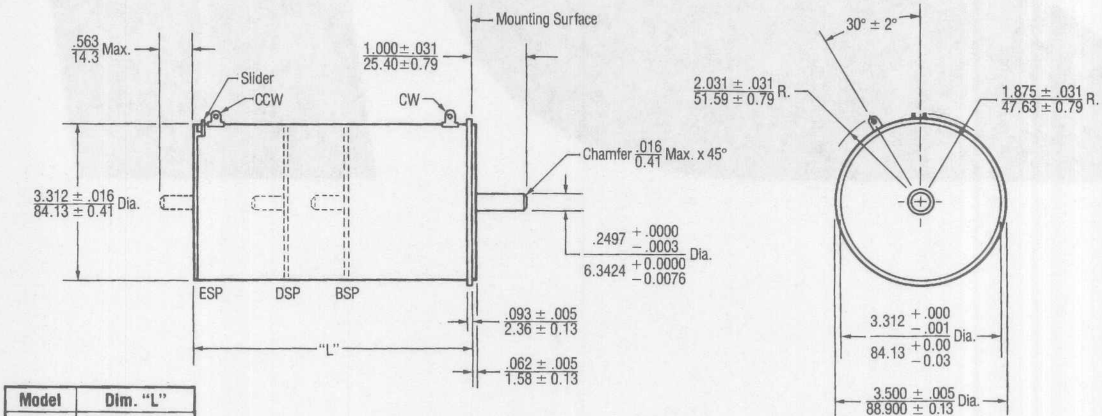


MODELS B, D & E (BUSHING MOUNT WITH SLEEVE BEARING)



Model	Dim. "L"
B	2.875 ± .031 / 73.03 ± 0.79
D	4.141 ± .047 / 105.2 ± 1.19
E	6.016 ± .047 / 152.8 ± 1.19

MODELS BSP, DSP & ESP (SERVO MOUNT WITH BALL BEARING)



Model	Dim. "L"
BSP	2.828 ± .031 / 71.83 ± 0.79
DSP	4.062 / 103.2 Max.
ESP	5.937 / 150.8 Max.

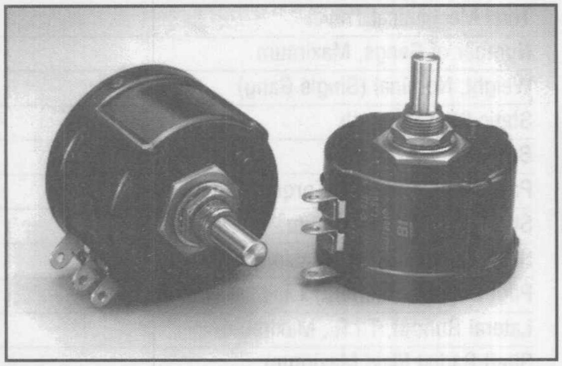
MODEL C

1-13/16" Diameter

3-Turn

Wirewound

Precision Potentiometer



ELECTRICAL

Resistance Range, Ohms	5 to 194.7K
Standard Resistance Tolerance	< 100 Ohms = ±5%, ≥ 100 Ohms = ±3%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.50%
Minimum Practical Independent Linearity	±0.5%, ≤ 25 Ohms ±0.25%, 26-99 Ohms ±0.15%, 100-1K Ohms ±0.10%, >1K Ohms
Power Rating, Watts	3.0 at 40°C derating to 0 at 85°C
Input Voltage, Maximum	1,000V dc not to exceed power rating
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	500 Ohms: RT ≤ 800 Ohms 250 Ohms: RT > 800 Ohms
Actual Electrical Travel	1080° + 4° – 0°
Tap Tolerance	≤ 25 Ohms = ±2°, < 100 Ohms = ±1.5° ≥ 100 Ohms = ±1.0°
End Voltage, Maximum (% of Input Voltage)	<100Ω = 1%, >100Ω = .5%

This model available in a hybrid version – contact factory for details.

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	Static: –65°C to +85°C Dynamic: –40°C to +85°C
Temperature Cycling	5 cycles, –65°C to +85°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (5% ΔRT, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 85°C (5% ΔR)
Rotational Load Life	2 mil. shaft rev. + 900 hrs. at rated wattage at 40°C (5% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	1080° + 4° – 0°
Number of Gangs, Maximum	3
Weight, Nominal (Single Gang)	2.5 oz.
Static Stop Strength	350 oz.-in.
Backlash, Maximum	1°
Panel Nut Tightening Torque, Maximum	25 lb.-in.
Shaft End Play, Maximum	.005"
Shaft Runout, T.I.R., Maximum	.0005"
Pilot Diameter Runout, T.I.R., Maximum	.002"
Lateral Runout, T.I.R., Maximum	.003"
Shaft Radial Play, Maximum	.004"
Start/Run Torque, Maximum (per gang)	3.0 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
100	0.084	±20 ppm/°C
200	0.074	± 20 ppm/°C
500	0.056	± 20 ppm/°C
1K	0.051	*+ 130 ppm/°C
2K	0.044	*+ 130 ppm/°C
5K	0.032	*+ 130 ppm/°C
10K	0.027	*+ 130 ppm/°C
20K	0.021	± 20 ppm/°C
50K	0.017	± 20 ppm/°C
100K	0.015	±20 ppm/°C

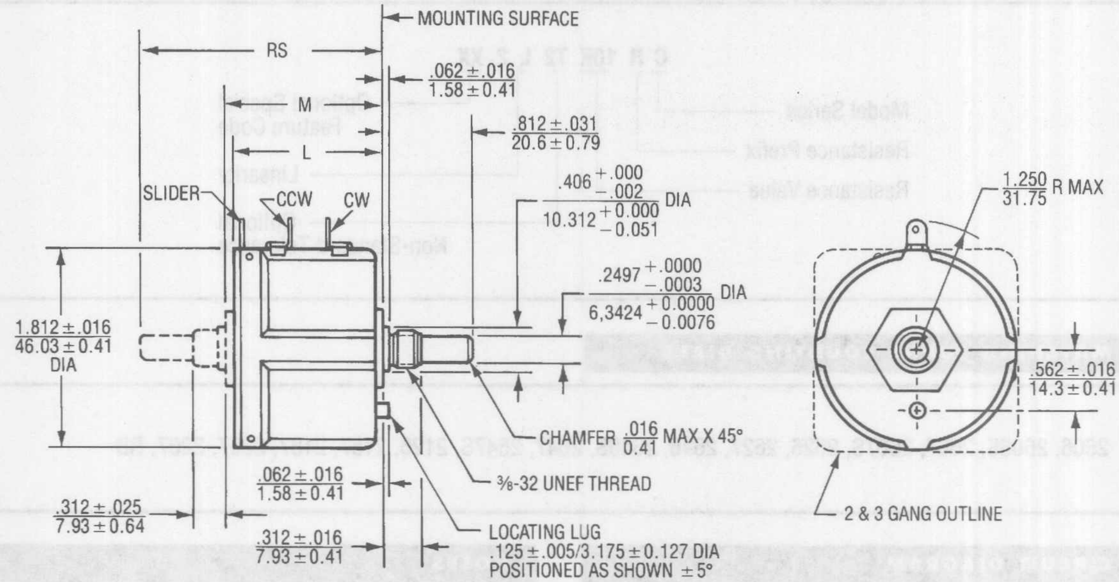
* Lower tempco available - contact factory for details.

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

OUTLINE DIMENSIONS

Dim. "L"	Dim. "M"	Dim. "RS"	No. of Gangs
1.141 / 28.98 MAX.	1.203 / 30.56	2.016 / 51.12	1
2.494 / 63.348 MAX.	2.480 / 62.992	3.297 / 83.744	2
3.534 / 89.764 MAX.	3.513 / 89.230	4.328 / 109.931	3



SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock	SL
Color Coded	CC
Additional Gangs	2G or 3G

ORDERING INFORMATION

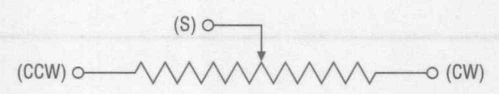
C R 10K T2 L .2 XX

- C — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T2 — Optional Non-Standard Tolerance
- L .2 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

2606, 2606S, 2607, 2607S, 2626, 2627, 2646, 2646S, 2647, 2647S, 2126, 2157, 2167, 2257, 2267, RB

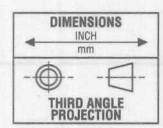
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



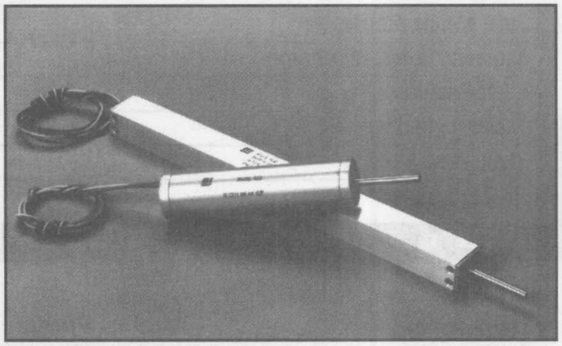
MODEL SERIES 400

Linear Actuation

Conductive Plastic

Precision Potentiometer /

Position Sensor



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MODEL STYLES

Model #	Body Style	Termination Style	Weight (grams)
423	Round	Wire Leads	28 + (16 x mechanical travel)
424	Round	Gold Plated Terminals	28 + (16 x mechanical travel)
432	Round with Mounting Flange	Wire Leads	38 + (16 x mechanical travel)
434	Round with Mounting Flange	Gold Plated Terminals	38 + (16 x mechanical travel)
472	Rectangular	Wire Leads	21 + (12 x mechanical travel)
474	Rectangular	Gold Plated Terminals	21 + (12 x mechanical travel)
482	Rectangular with Mounting Flange	Wire Leads	23 + (12 x mechanical travel)
484	Rectangular with Mounting Flange	Gold Plated Terminals	23 + (12 x mechanical travel)

ELECTRICAL

Resistance Range, Ohms	See Table 1
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity	See Table 1
Minimum Practical Independent Linearity	See Table 1
Input Voltage, Maximum	400V dc, but not to exceed power rating
Power Rating, Watts	See Table 1
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1% at 10" to 18"/ Minute
Actual Electrical Travel, Nominal	See Table 1
Electrical Continuity Travel, Minimum	Within Mechanical Travel
Resolution	Essentially infinite
Temperature Coefficient*	–800 ppm/°C

*Special tempco available to ±100ppm/°C.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –55°C to +125°C Dynamic: –40°C to +125°C
Load Life	10 mil. shaft actuations (10% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	See Table 1
Actuating Force, Maximum	10 oz.
Shaft Rotation	Continuous
Backlash, Maximum	.003"
Static Stop Strength	10 lb.

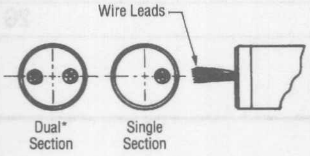
TABLE 1

Electrical Travel, Inches (Ordering #)	**0.5" (-050)**	**1.0" (-100)**	**2.0" (-200)**	**3.0" (-300)**
Standard Resistance Range, Ohms	1K to 150K	2K to 300K	4K to 600K	8K to 900K
Standard Independent Linearity	±1.0%	±0.75%	±0.5%	±0.5%
Minimum Practical Independent Linearity	0.5%	0.25%	0.25%	0.25%
Power Rating, Watts	0.5	0.75	1.0	1.5
Mechanical Travel, Inches	0.6"	1.1"	2.1"	3.1"

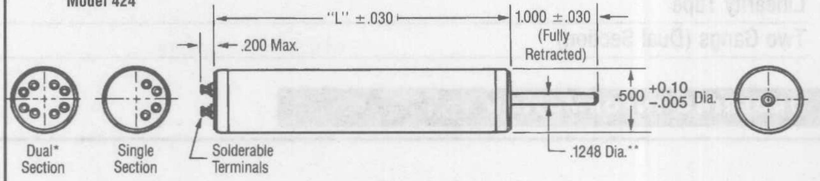
Electrical Travel, Inches (Ordering #)	**4.0" (-400)**	**5.0" (-500)**	**6.0" (-600)**
Standard Resistance Range, Ohms	1.2K to 1Meg	1.5K to 1.3Meg	2K to 1.5Meg
Standard Independent Linearity	±0.5%	±0.5%	±0.25%
Minimum Practical Independent Linearity	0.25%	0.25%	0.15%
Power Rating, Watts	2.0	2.5	3.0
Mechanical Travel, Inches	4.1"	5.1"	6.1"

2

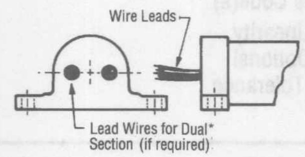
WIRE LEAD MODEL
Model 423



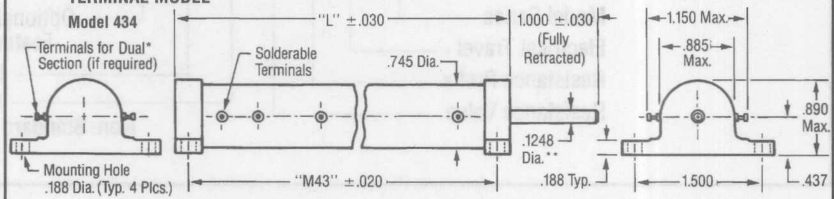
TERMINAL MODEL
Model 424



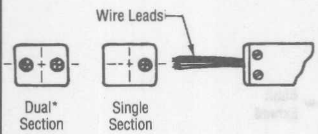
WIRE LEAD MODEL
Model 432



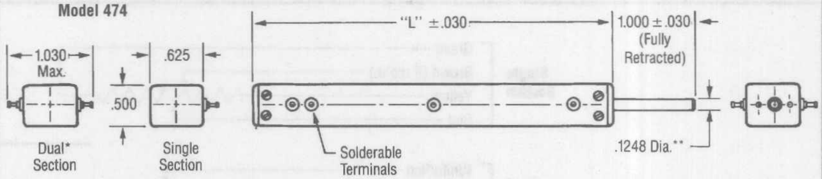
TERMINAL MODEL
Model 434



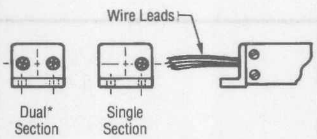
WIRE LEAD MODEL
Model 472



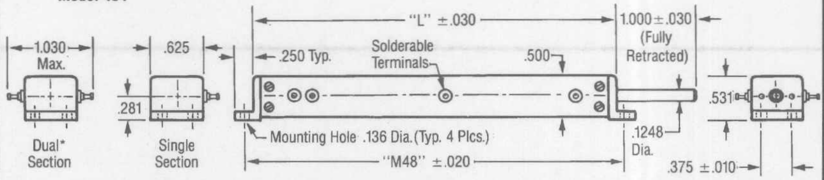
TERMINAL MODEL
Model 474



WIRE LEAD MODEL
Model 482



TERMINAL MODEL
Model 484



Model Number	Elect. Travel Inch ±.015	Mech. Travel Inch ±.030	Dim "L" Inch ±.030	Dim "M43" Inch ±.020	Dim "M48" Inch ±.020
4XX-050	.500	.560	1.415	1.188	1.750
4XX-100	1.000	1.060	1.915	1.688	2.250
4XX-200	2.000	2.060	2.915	2.688	3.250
4XX-300	3.000	3.060	3.915	3.688	4.250
4XX-400	4.000	4.100	5.000	4.688	5.250
4XX-500	5.000	5.100	6.000	5.688	6.250
4XX-600	6.000	6.100	7.000	6.688	7.250

Notes:

- The dimensions for "Wire Lead" models are the same as the "Terminal" models, except as indicated.
- Housing, Brackets and Caps: Aluminum (Anodized).
- Wire Leads: #26 lead wire, 12 inch minimum length (Meets MIL-W-16878C).
- * Dual Sections and Center Tap are available on special order only.
- Shafts: Stainless Steel (Passivated). Chamfer is .015 x 45°.

  ** Diameter is $.1248^{+.0000}_{-.0003}$
- Unspecified Tolerance: ± .005.

SPECIAL FEATURE CODES

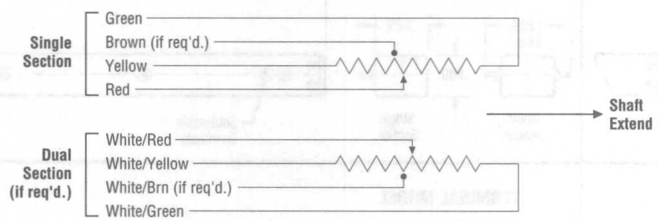
Center Tap	CT
Linearity Tape	LT
Two Gangs (Dual Section)	2G

ORDERING INFORMATION

423 600 R 10K T5 L.25 XX

- 423 — Model Series
- 600 — Electrical Travel
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L.25 — Linearity
- XX — Optional Special Feature Code(s)

CIRCUIT DIAGRAM

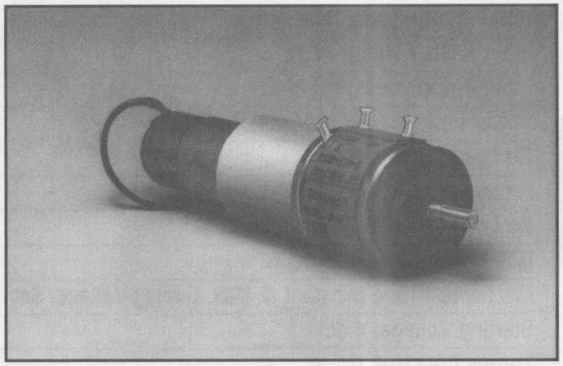


SERIES 920, 930, 940

Precision Motor Potentiometers

BI Motor Potentiometers use a precision potentiometer connected to a DC motor by a gear box and clutch. There are eight potentiometer types and 15 gear ratios available combined with a 10,700 RPM motor.

In addition, motor potentiometers with special features such as center-taps, multi-taps, special shafts, and special gear ratios, etc., can be provided on special orders. Several potentiometer sections can be ganged on a single rotor potentiometer shaft.



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SPECIFICATIONS

Motor Potentiometer Model	922	927	929	931
Potentiometer Model	6671	8146	8211	A
# of Turns	1	10	10	10
Element Type	Conductive Plastic	Hybrid	Hybrid	Wirewound
Potentiometer Mounting Style	Bushing	Bushing	Bushing	Bushing
Resistance Range, Ohms	1K-300K	1K-100K	1K-25K	10-500K
Diameter	2"	7/8"	2"	1 -13/16"
Linearity	±0.25%	±0.25%	±0.5%	<300Ω: ±0.5% ≥300Ω: ±0.25%
No. of Gangs, Max.	3	2	3	3

Motor Potentiometer Model	933	936	937	949
Potentiometer Model	C	7283	7286	5611
# of Turns	3	10	10	1
Element Type	Wirewound	Wirewound	Wirewound	Wirewound
Potentiometer Mounting Style	Bushing	Servo	Bushing	Bushing
Resistance Range, Ohms	100-100K	100-100K	100-100K	1K - 50K
Diameter	1-13/16"	7/8"	7/8"	2"
Linearity	±0.5% ≥1KΩ:0.20%	≤75Ω:±0.50%	±0.25%	<50Ω: ±1.0% ≥50Ω: ±0.5%
No. of Gangs, Max.	3	2	2	3

Refer to potentiometer data sheet for complete specifications.
Specifications subject to change without notice.

MOTOR SPECIFICATIONS

Rotor Temperature, °C	22
Input Voltage Range, V dc	Vis to 9.0
Input Voltage, Nominal, V dc	6.0*
Power Input @ Stall (6 V dc), Watts	1.8
No Load Current, mA	≤7
Armature Resistance, Ohms	20
No Load Speed @ Max. Volts, RPM	16,000
No Load Speed (6.0 V dc, RPM)	10,700
Mechanical Time constant @ Max. Supply Voltage, Sec.	0.032
Starting Voltage, V dc	0.3
Torque Constant, oz.-in.	0.749
Torque Stall (6.0 V dc), oz.-in. Max.	0.22
Torque Continuous Duty (Gear Box), oz.-in. Max.	3
Moment of Inertia, oz.-in. /Sec^2	5.6×10^{-6}
Motor Pot Life Expectancy @ Rated Torque, Hours	5,000
Slip Friction Setting, oz.-in., Nominal	12
Life Reduction per Load Torque Beyond Rating, Estimated Hours	643 (T_L^{-3})

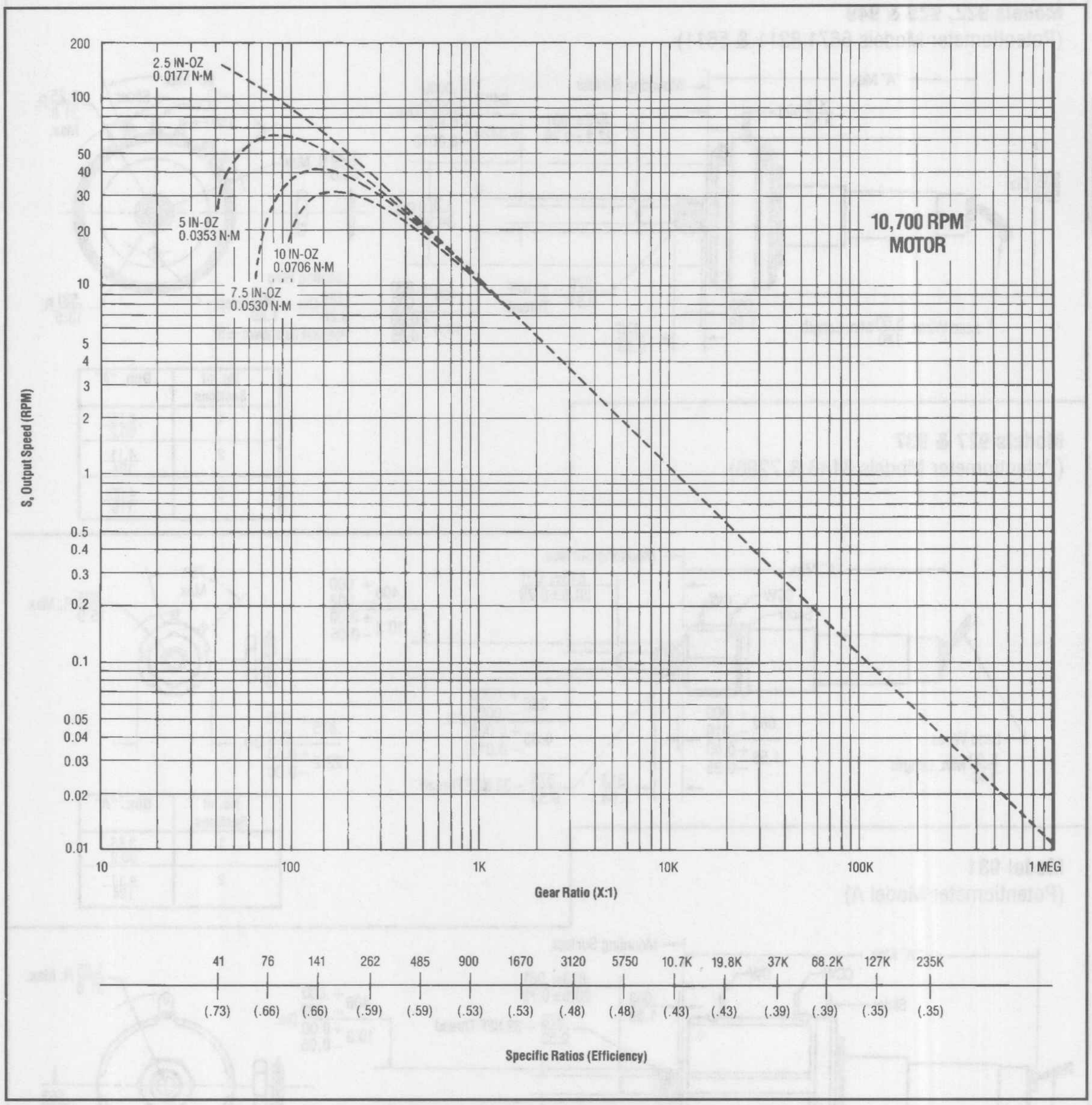
*Input voltage in continuous stall and 22°C ambient.

GEAR RATIO SPECIFICATIONS

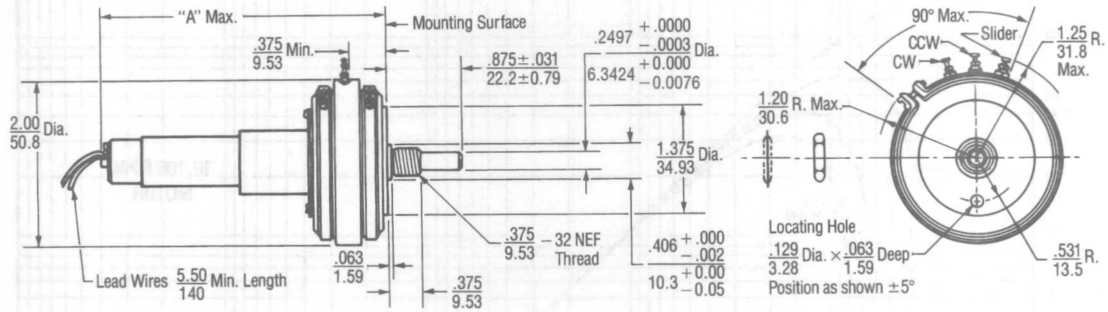
Gear Ratio (N)	Output Speed (RPM)	Efficiency (e)	Backlash Max. (B)	Direction(D)**
41:1†	261	.73	4°	CW
76:1	141	.66	4°	CCW
141:1†	76	.66	4°	CCW
262:1†	41	.59	4°	CW
485:1	22	.59	4°	CW
900:1	12	.53	4°	CCW
1,670:1	6.4	.53	4°	CCW
3,101:1	3.5	.48	4°	CW
5,752:1	1.9	.48	4°	CW
10,683:1	1.0	.43	4°	CW
19,813:1	0.54	.43	4°	CCW
36,796:1	0.29	.39	4°	CW
68,245:1	0.17	.39	4°	CW
126,741:1	0.08	.35	4°	CCW
235,067:1	0.05	.35	4°	CCW

** Direction of shaft rotation with "+" voltage to red lead.
† Stocked ratios.

OUTPUT SPEED VS. GEAR RATIO AT VARIOUS LOAD TORQUES

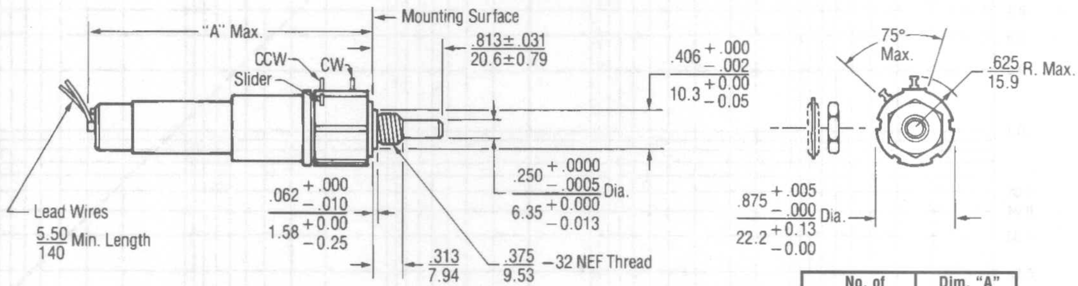


Models 922, 929 & 949
(Potentiometer Models 6671,8211 & 5611)



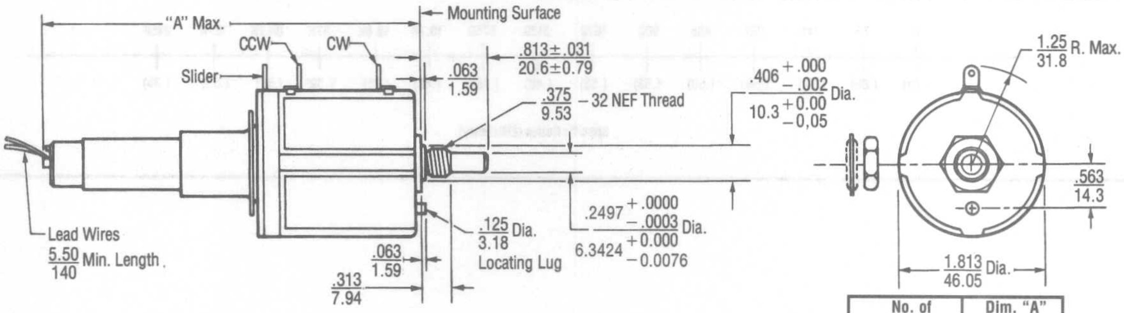
No. of Sections	Dim. "A"
1	3.55/90.2
2	4.11/104
3	4.68/119

Models 927 & 937
(Potentiometer Models 8146 & 7286)



No. of Sections	Dim. "A"
1	3.55/90.2
2	4.11/104

Model 931
(Potentiometer Model A)



No. of Sections	Dim. "A"
1	4.63/118
2	6.83/174
3	8.73/222

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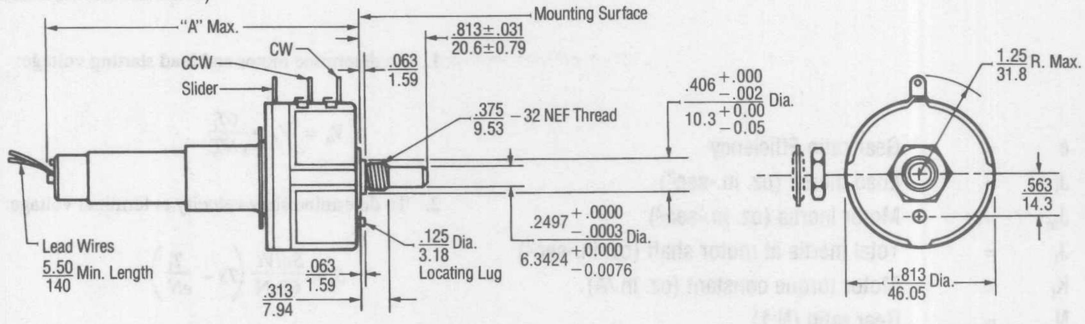
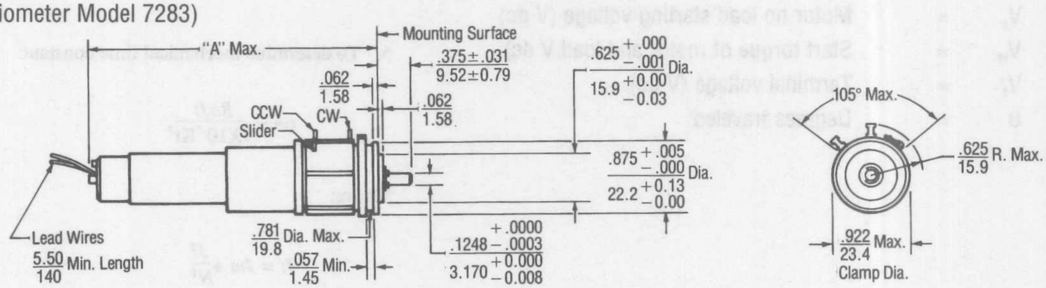
Model 933
(Potentiometer Model C)



No. of Sections	Dim. "A"
1	3.70 / 95.8
2	5.05 / 129
3	6.09 / 155

Model 936
(Potentiometer Model 7283)



No. of Sections	Dim. "A"
1	3.50 / 88.9
2	4.19 / 106

MOTOR POT AND LOAD PERFORMANCE CALCULATIONS

e	=	Gear ratio Efficiency
J_l	=	Load inertia (oz. in.-sec^2)
J_m	=	Motor inertia (oz. in.-sec^2)
J_t	=	Total inertia at motor shaft (oz. in.-sec^2)
K_t	=	Motor torque constant (oz. in./A)
N	=	Gear ratio (N:1)
R_a	=	Armature d-c resistance (ohms)
S_{ni}	=	No load motor speed at rated voltage (RPM)
S_o	=	Slew velocity (RPM)
t	=	Travel time (seconds)
T_l	=	Load torque (oz. in.) Must include pot
t_m	=	Mechanical time constant (seconds)
T_s	=	Motor stall torque at rated voltage (oz. in.)
V_s	=	Motor no load starting voltage (V dc)
V_{ls}	=	Start torque of motor and load V dc)
V_t	=	Terminal voltage (V dc)
θ	=	Degrees traveled

1. To determine motor and load starting voltage:

$$V_{ls} = V_s + \frac{6T_l}{eNT_s}$$

2. To determine slew velocity at terminal voltage:

$$S_o = \frac{SnlVt}{6TsN}\left(Ts - \frac{T_l}{eN}\right)$$

3. To determine gear ratio:

$$N = \frac{Snl}{2So}\left(1 + \sqrt{1 - \frac{4TlSo}{TsSnl}}\right)$$

4. To determine degrees traveled:

$$\theta = 6So[t - tm(1 + 2.72^{-t/tm})]$$

5. To determine mechanical time constant:

$$tm = \frac{RaJt}{7X10^{-3}Kt^2}$$

Where:

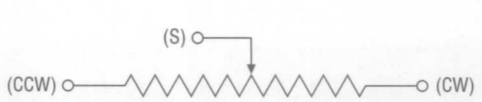
$$Jt = Jm + \frac{Jl}{N^2}$$

ORDERING INFORMATION

927 R5K T5 L.25 G485

- 927 — Model Series
- R5K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L.25 — Linearity
- G485 — Gear Ratio

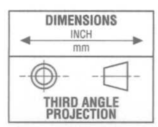
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

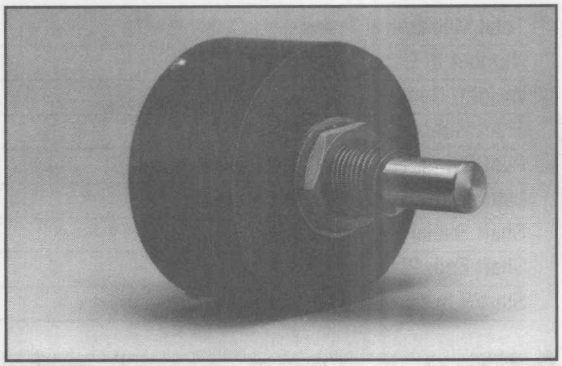
Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL 3371

1-5/16" Diameter
Single Turn
Conductive Plastic
Precision Potentiometer /
Position Sensor

Distributor Item



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ELECTRICAL

Resistance Range, Ohms	1K to 900K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity*	±0.5%
Minimum Practical Independent Linearity	±0.25%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	.75 at 65°C derating to 0 at 105°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	348°
Electrical Continuity Travel, Minimum	350°
End Voltage, Maximum	0.5% of Input Voltage
Tap Tolerance	0.5% of Input Voltage
Resolution	Essentially infinite
Temperature Coefficient**	–800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ± 100ppm/°C.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	–25°C to +105°C
Temperature Cycling	5 cycles, –25°C to +105°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (25% ΔR)
High Temperature Exposure	Mechanical operation at 105°C (0.5% ΔR)
Rotational Life	2 mil. shaft rev.
Rotational Load Life	2 mil. shaft rev. (10% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	360° continuous (350° ±2° with stop feature)
Number of Gangs, Maximum	1
Weight, Nominal	1.5 oz.
Shaft Runout, T.I.R., Maximum	.0025”
Pilot Diameter Runout, T.I.R., Maximum	.0025”
Lateral Runout, T.I.R., Maximum	.003”
Shaft Radial Play, Maximum	.004”
Shaft End Play, Maximum	.007”
Start/Run Torque, Maximum	1.0 oz.-in

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock	SL
Stop	ST

FEATURES/BENEFITS

- Low noise
- Excellent “output” smoothness

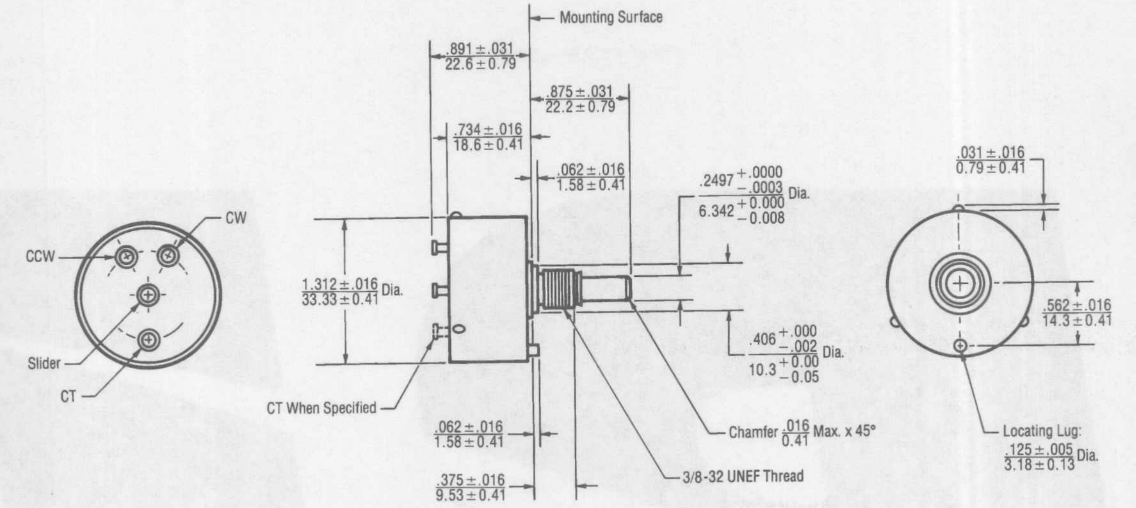
STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K	100K

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

OUTLINE DIMENSIONS

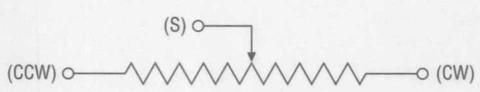


ORDERING INFORMATION

3371 R 10K T5 L.5 XX

- 3371 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L.5 — Linearity
- XX — Optional Special Feature Code

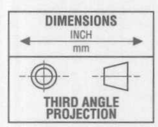
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

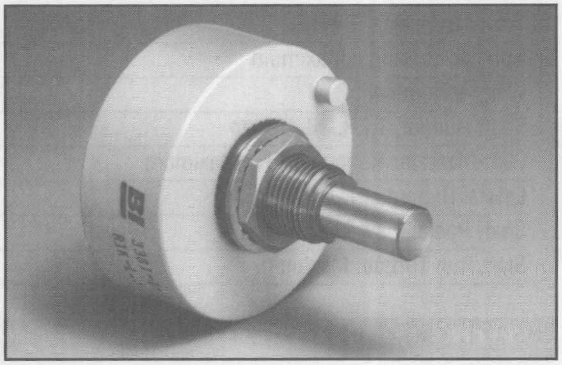
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL 3381

1-5/16" Diameter
Single Turn
Conductive Plastic
Precision Potentiometer/
Position Sensor

Distributor Item



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ELECTRICAL

Resistance Range, Ohms	1K to 300K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity*	±0.5%
Minimum Practical Independent Linearity	±0.25%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	2.0 at 70°C derating to 0 at 105°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	348°
Electrical Continuity Travel, Minimum	350°
End Voltage, Maximum	0.5% of Input Voltage
Tap Tolerance	0.5% of Input Voltage
Resolution	Essentially infinite
Temperature Coefficient**	–800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ± 100ppm/°C.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: – 40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (25% ΔR)
High Temperature Exposure	Mechanical operation at 125°C (0.5% ΔR)
Rotational Life	10 mil. shaft rev.
Rotational Load Life	10 mil. shaft rev. (10% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	360° continuous (350° ±2° with stop feature)
Number of Gangs, Maximum	1
Weight, Nominal	1.5 oz.
Shaft Runout, T.I.R., Maximum	.0025"
Pilot Diameter Runout, T.I.R., Maximum	.0025"
Lateral Runout, T.I.R., Maximum	.003"
Shaft Radial Play, Maximum	.004"
Start/Run Torque, Maximum	1.0 oz.-in.

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Flatted Shaft	FS
Slotted Shaft	SS
Stop	ST
Shaft Lock	SL

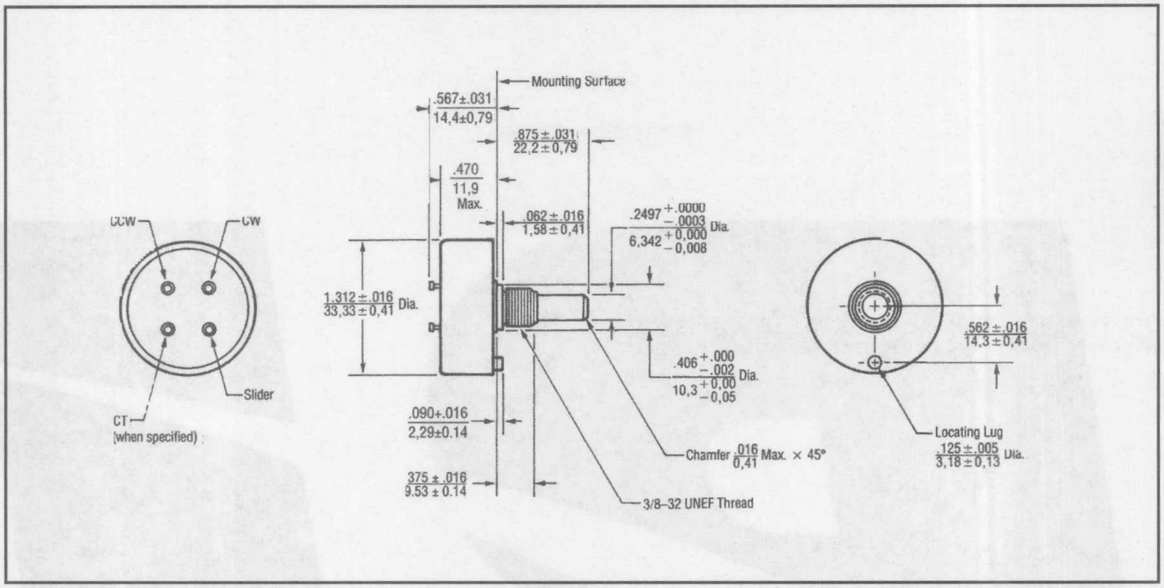
STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K	100K

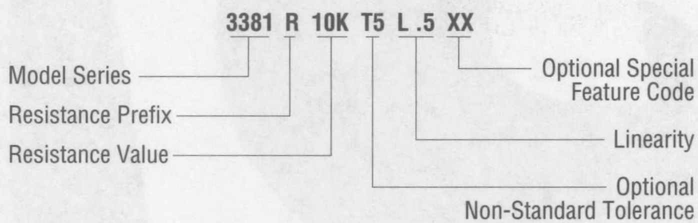
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

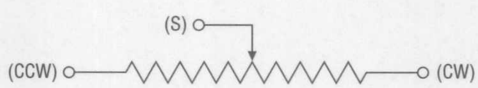
OUTLINE DIMENSIONS



ORDERING INFORMATION



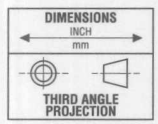
CIRCUIT DIAGRAM



NOTES

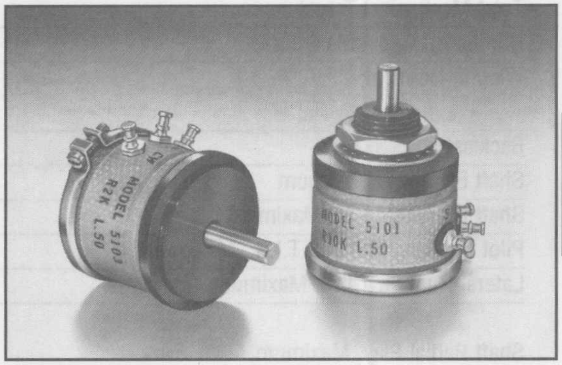
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 5100

7/8" Diameter
Single Turn
Wirewound
Precision Potentiometer



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MODEL STYLES

5101	1/8" Shaft, 3/8" Bushing
5103	1/8" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	200 to 15K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±2%
Independent Linearity	±0.5%
Minimum Practical Independent Linearity	±0.25%
Power Rating, Watts	0.75 at 40°C derating to 0 at 85°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	354° + 2°
Tap Tolerance	±2° <500 Ohms, ±1° ≥500 Ohms
End Voltage, Maximum	Within Std. Linearity Tolerance

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	–25°C to +85°C
Temperature Cycling	5 cycles, –25°C to +85°C
Shock, 6ms Sawtooth	100G's
Vibration	10G's, 10 to 500 Hz
Humidity	Five 24 hour cycles
Rotational Load Life	500K shaft rev. plus 900 hrs. at rated wattage at 40°C

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel		360° Continuous
Number of Cups, Maximum		4
Weight, Nominal		0.5 oz. Single Cup 0.3 oz. Each Added Cup
Backlash		Negligible
Shaft End Play, Maximum		.005"
Shaft Runout, T.I.R., Maximum		.0015"
Pilot Diameter Runout, T.I.R., Maximum		.002"
Lateral Runout, T.I.R., Maximum		.003"
	5101	**5103**
Shaft Radial Play, Maximum	.003"	.0025"
Start/Run Torque, Maximum	0.2 oz.-in.	0.2 oz.-in.

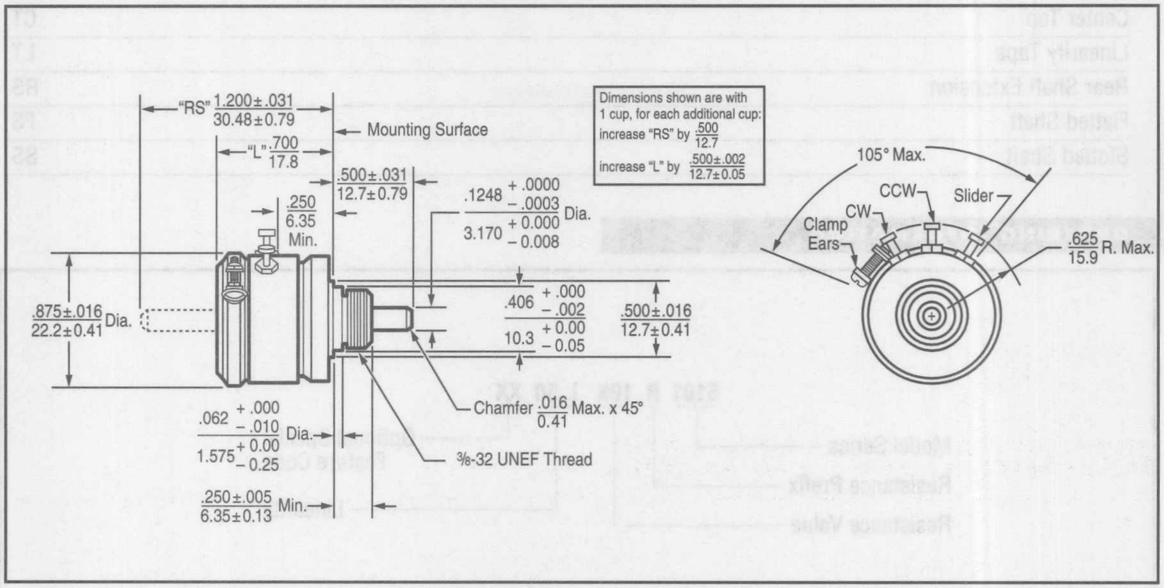
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
1K	0.210	±20 ppm/°C
2K	0.170	±20 ppm/°C
5K	0.140	±20 ppm/°C
10K	0.110	±20 ppm/°C
15K	0.100	±20 ppm/°C

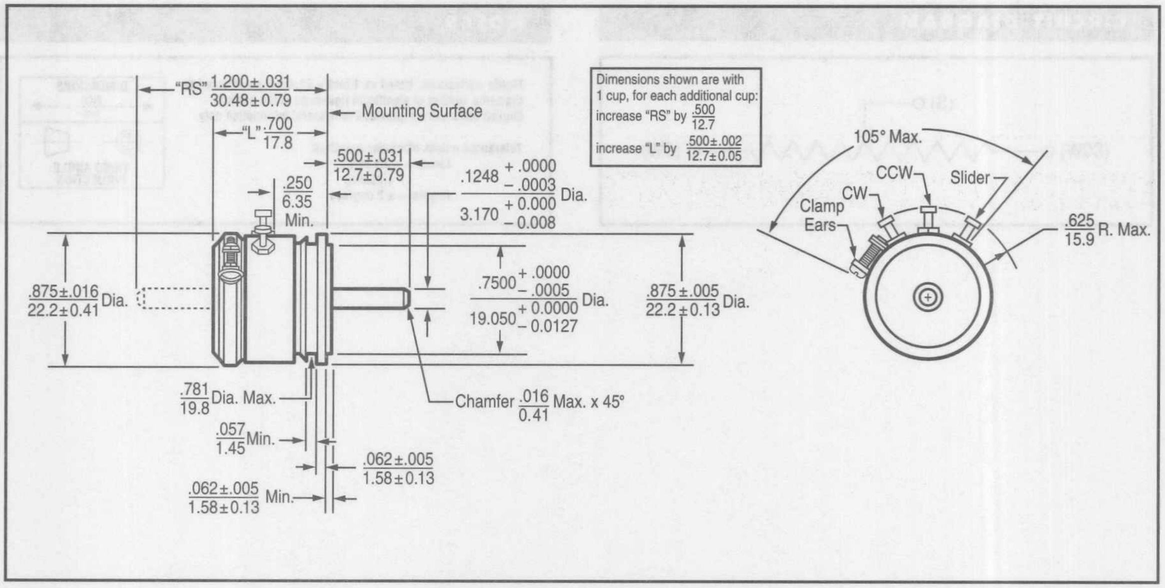
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

MODEL 5101



MODEL 5103



SPECIAL FEATURE CODES

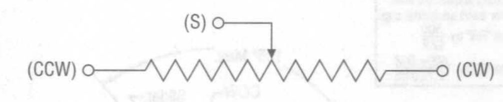
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS

ORDERING INFORMATION

5101 R 10K L.50 XX

- Model Series — 5101
- Resistance Prefix — R
- Resistance Value — 10K
- Linearity — L.50
- Optional Special Feature Code — XX

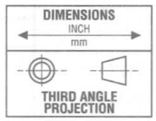
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



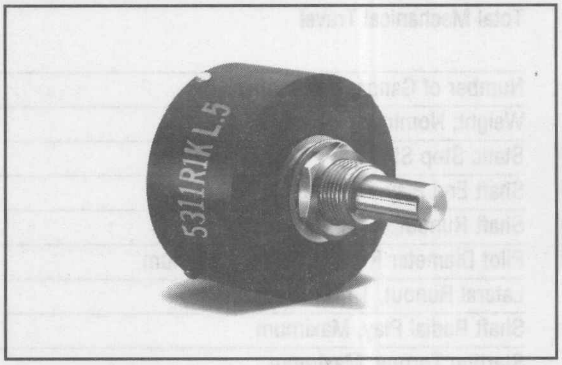
MODEL 5311

1-5/16″ Diameter

Single Turn

Wirewound

Precision Potentiometer



ELECTRICAL

Resistance Range, Ohms	10 to 44.6K
Standard Resistance Tolerance	±3% (±5% ≤40 Ohms)
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.5% (±1% ≤250 Ohms)
Minimum Practical Independent Linearity	±1.0%, ≤40 Ohms ±0.75%, 41-99 Ohms ±0.5%, 100-249 Ohms ±0.25%, ≥250 Ohms
Input Voltage	400V dc not to exceed power rating
Power Rating, Watts	2.0 at 40°C derating to 0 at 85°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms (250 Ohms: RT ≤500 Ohms)
Actual Electrical Travel	352° ±2 °Continuous model 350° ±2° Stop model
Tap Tolerance	±1° (±2° <100 Ohms)
End Voltage, Maximum	Linearity x Input Voltage

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	−25°C to +85°C
Temperature Cycling	5 cycles, -25°C to +85°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 85°C (5%ΔR)
Rotational Load Life	500K shaft rev. at rated wattage at 85°C (5% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	360° Continuous model 350° ±2° Stop model
Number of Gangs, Maximum	1
Weight, Nominal	1.5 oz.
Static Stop Strength	48 oz.-in.
Shaft End Play, Maximum	.007"
Shaft Runout, T.I.R., Maximum	.0025"
Pilot Diameter Runout, T.I.R., Maximum	.0025"
Lateral Runout, T.I.R., Maximum	.003"
Shaft Radial Play, Maximum	.004"
Starting Torque, Maximum	1.0 oz.-in.
Running Torque, Maximum	0.7 oz.-in.

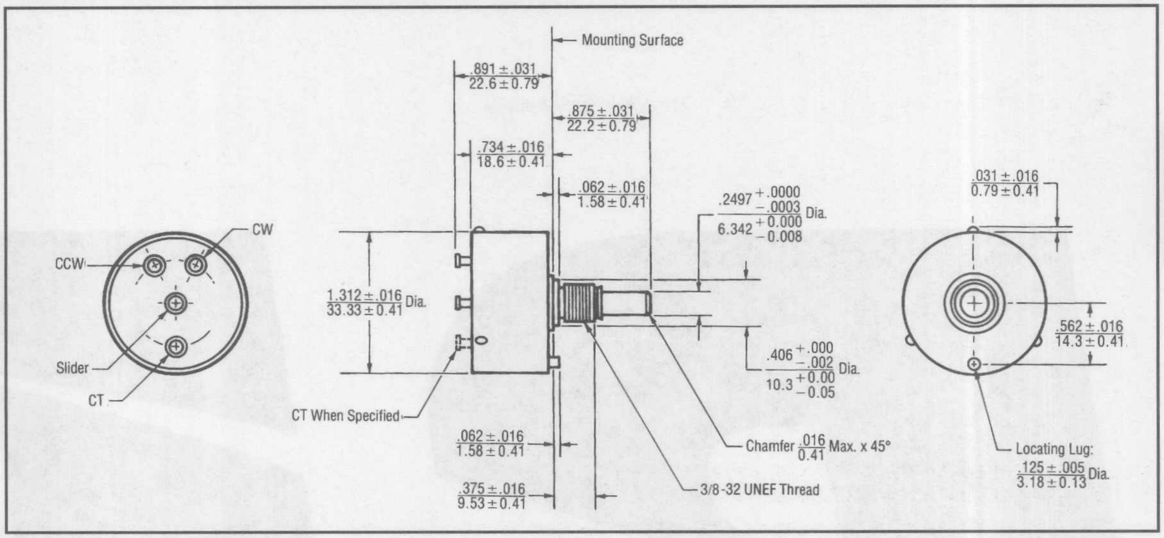
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
10	0.491	± 20 ppm/°C
100	0.233	± 20 ppm/°C
500	0.187	± 20 ppm/°C
1K	0.150	± 20 ppm/°C
2K	0.117	± 20 ppm/°C
5K	0.090	± 20 ppm/°C
10K	0.073	± 20 ppm/°C
20K	0.066	± 20 ppm/°C
30K	0.060	± 20 ppm/°C

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

OUTLINE DIMENSIONS



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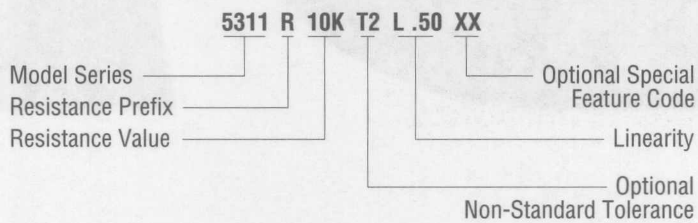
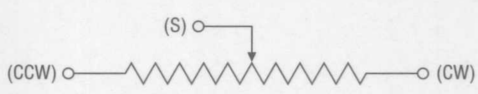
SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock	SL
Stop	ST

ORDERING INFORMATION



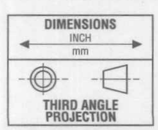
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



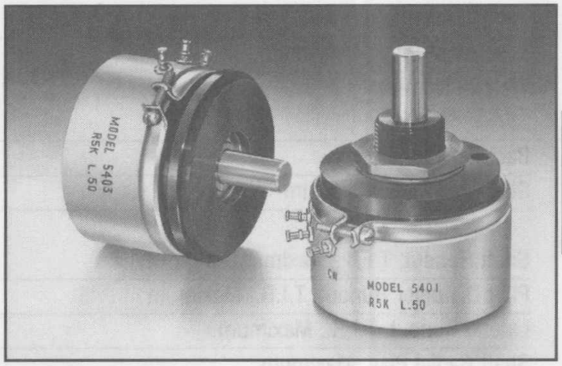
MODEL SERIES 5400

1-7/16" Diameter

Single Turn

Wirewound

Precision Potentiometer



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MODEL STYLES

5401	1/4" Shaft, 1/2" Bushing
5403	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	25 to 50K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±1.0%, <100 Ohms ±0.5%, ≥100 Ohms
Minimum Practical Independent Linearity	±1%, <100 Ohms ±0.5%, 100-1,999 Ohms ±0.25%, 2K-9,999 Ohms ±0.15%, ≥10K Ohms
Power Rating, Watts	2.0 at 80°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	354° ± 2°
Tap Tolerance	±1°
End Voltage, Maximum	Within Std. Linearity Tolerance

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	–65°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1%ms discontinuity, max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1%ms discontinuity, max.)
Humidity	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	At rated wattage at 70°C (5% ΔR) 5401: 500K shaft rev. plus 900 hrs. 5403: 1 mil. shaft rev. plus 900 hrs.

Specifications subject to change without notice.

MECHANICAL

	5401	5403
Total Mechanical Travel		360° Continuous
Number of Cups, Maximum		4
Weight, Nominal		2.0 oz. Single Cup 0.7 oz. Each Added Cup
Backlash, Maximum		Negligible
Shaft End Play, Maximum		.005"
	5401	**5403**
Shaft Runout, T.I.R., Maximum	.005"	.001"
Pilot Diameter Runout, T.I.R., Maximum	.001"	.0015"
Lateral Runout, T.I.R., Maximum	.0025"	.004"
Shaft Radial Play, Maximum	.0015"	.004"
Starting Torque, Maximum (per gang)	1.6 oz.-in.	0.6 oz.-in.
Running Torque, Maximum (per gang)	0.8 oz.-in.	0.4 oz.-in.

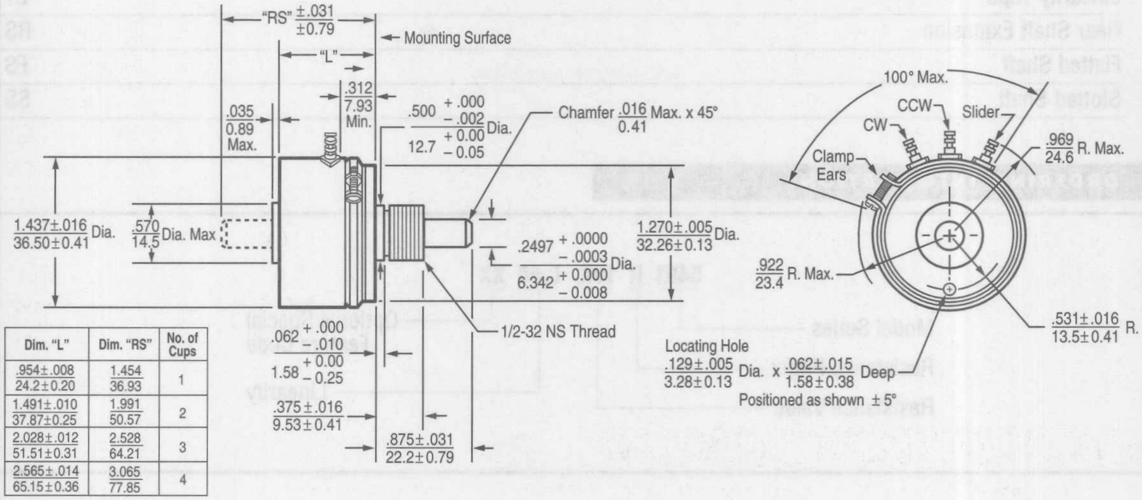
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
1K	0.125	±130 ppm/°C
2K	0.106	±130 ppm/°C
5K	0.081	±20 ppm/°C
10K	0.073	±20 ppm/°C
20K	0.059	±20 ppm/°C

METRIC CONVERSIONS

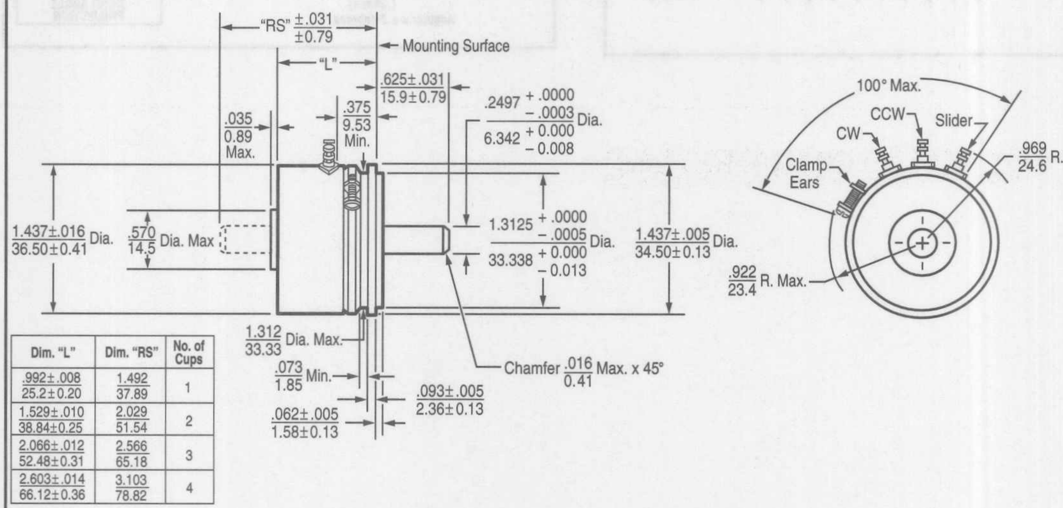
1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

MODEL 5401



Dim. "L"	Dim. "RS"	No. of Cups
.954±.008 / 24.2±0.20	1.454 / 36.93	1
1.491±.010 / 37.87±0.25	1.991 / 50.57	2
2.028±.012 / 51.51±0.31	2.528 / 64.21	3
2.565±.014 / 65.15±0.36	3.065 / 77.85	4

MODEL 5403



Dim. "L"	Dim. "RS"	No. of Cups
.992±.008 / 25.2±0.20	1.492 / 37.89	1
1.529±.010 / 38.84±0.25	2.029 / 51.54	2
2.066±.012 / 52.48±0.31	2.566 / 65.18	3
2.603±.014 / 66.12±0.36	3.103 / 78.82	4

SPECIAL FEATURE CODES

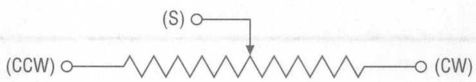
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS

ORDERING INFORMATION

5401 R 10K L.50 XX

- 5401 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- L.50 — Linearity
- XX — Optional Special Feature Code

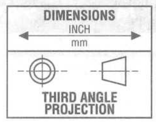
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



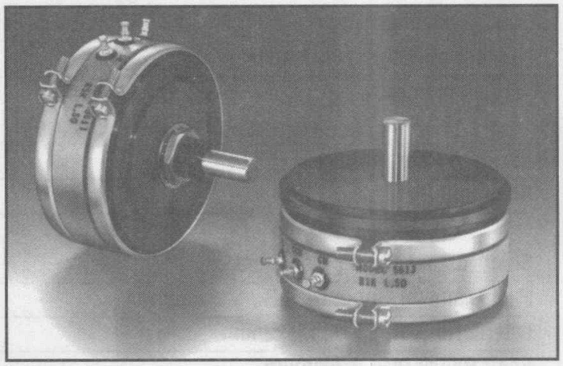
MODEL SERIES 5610

2" Diameter

Single Turn

Wirewound

Precision Potentiometer



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MODEL STYLES

5611	1/4" Shaft, 3/8" Bushing
5613	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	15 to 80K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1.0%
Independent Linearity	±1.0% <50 Ohms ±0.5% ≥50 Ohms
Minimum Practical Independent Linearity	±1.0%, <50 Ohms ±0.5%, 50-499 Ohms ±0.25%, 500-4,999 Ohms ±0.1%, ≥5K Ohms
Power Rating, Watts	3.5 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	356° + 1°
Tap Tolerance	±1°
End Voltage, Maximum	Linearity x Input Voltage

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, -65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	50G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Life	1 Mil. Shaft Rev.
Rotational Load Life	1 mil. shaft rev. at rated wattage at 70°C (5% ΔR)

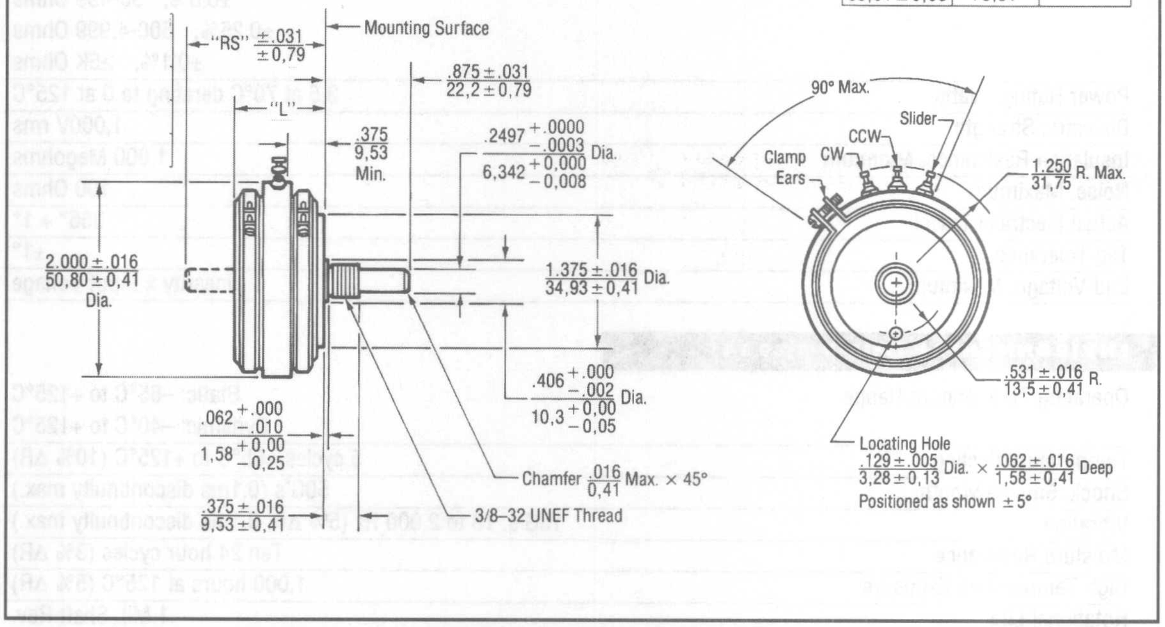
Specifications subject to change without notice.

MECHANICAL

	5611	5613
Total Mechanical Travel		360° Continuous
Number of Gangs, Maximum		4
Weight, Nominal		3.7 oz. Single Gang 1.3 oz. Each Added Gang
Backlash, Maximum		1°
Shaft End Play, Maximum		.005"
Shaft Runout, T.I.R., Maximum	.0005"	.001"
Pilot Diameter Runout, T.I.R., Maximum	.002"	.0015"
Lateral Runout, T.I.R., Maximum	.004"	.006"
Shaft Radial Play, Maximum	.004"	.002"
Starting Torque, Maximum (per gang)	1.5 oz.-in.	0.8 oz.-in.
Running Torque, Maximum (per gang)	1.1 oz.-in.	0.6 oz.-in.

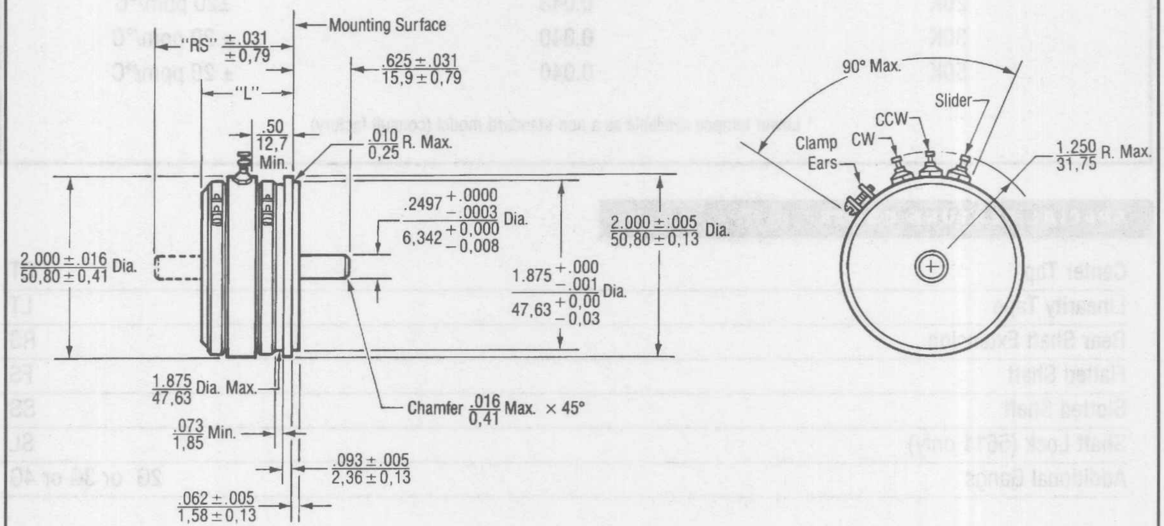
MODEL 5611 (BUSHING MOUNT WITH SLEEVE BEARING)

Dim. "L"	Dim. "RS"	No. of Cups
.905 ± .020 22,9 ± 0,51	1.405 35,69	1
1.467 ± 0.22 37,26 ± 0,56	1.967 49,96	2
2.029 ± .024 51,54 ± 0,61	2.529 64,24	3
2.591 ± .026 65,81 ± 0,66	3.091 78,51	4



MODEL 5613 (SERVO MOUNT WITH BALL BEARING)

Dim. "L"	Dim. "RS"	No. of Cups
1.020 ± .015 / 25,91 ± 0,38	1.520 / 38,61	1
1.582 ± .017 / 40,18 ± 0,43	2.082 / 52,88	2
2.144 ± .019 / 54,46 ± 0,48	2.644 / 67,16	3
2.706 ± .021 / 68,73 ± 0,53	3.206 / 81,43	4



METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
1K	0.089	*±130 ppm/°C
2K	0.071	*±130 ppm/°C
5K	0.058	±20 ppm/°C
10K	0.053	±20 ppm/°C
20K	0.043	±20 ppm/°C
30K	0.040	± 20 ppm/°C
50K	0.040	± 20 ppm/°C

* Lower tempco available as a non-standard model (consult factory)

SPECIAL FEATURE CODES

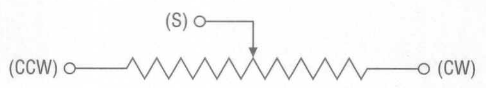
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock (5611 only)	SL
Additional Gangs	2G or 3G or 4G

ORDERING INFORMATION

5611 R 10K T2 L.50 XX

- 5611 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T2 — Optional Non-Standard Tolerance
- L.50 — Linearity
- XX — Optional Special Feature Code

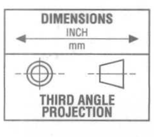
CIRCUIT DIAGRAM



NOTES

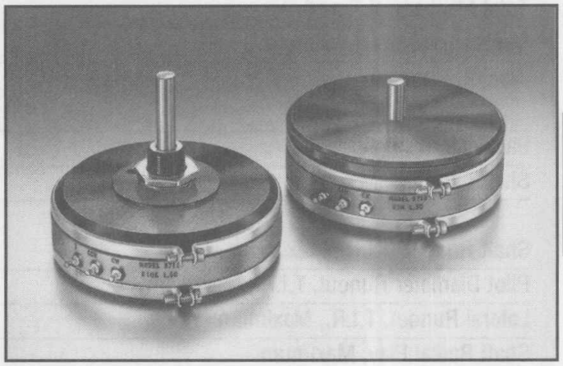
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 5710

3" Diameter
Single Turn
Wirewound
Precision Potentiometer



MODEL STYLES

5711	1/4" Shaft, 1/2" Bushing
5713	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	25 to 145K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.5%
Minimum Practical Independent Linearity	±0.5%, <75 Ohms ±0.25%, 75-249 Ohms ±0.15%, 250-6,999 Ohms ±0.075%, ≥7K Ohms
Power Rating, Watts	5.0 at 40°C derating to 0 at 105°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	358° ±1°
Tap Tolerance	±1°
End Voltage, Maximum	Within Std. Linearity Tolerance

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	–65°C to +105°C
Temperature Cycling	5 cycles, –65°C to +105°C
Shock, 6ms Half Sine	100G's
Vibration	5G's, 10 to 500 Hz
Moisture	Ten 24 hour cycles
High Temperature Exposure	1,000 hours at 105°C
Rotational Life	1 Mil. Shaft Rev.
Rotational Load Life	1 mil. shaft rev. plus 900 hrs. at rated wattage at 40°C

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel		360° Continuous
Number of Cups, Maximum		4
Weight, Nominal		5.8 oz. Single Cup 1.3 oz. Each Added Cup
Backlash, Maximum		1°
Shaft End Play, Maximum		.005"
	5711	**5713**
Shaft Runout, T.I.R., Maximum	.0005"	.001"
Pilot Diameter Runout, T.I.R., Maximum	.002"	.0015"
Lateral Runout, T.I.R., Maximum	.004"	.101"
Shaft Radial Play, Maximum	.004"	.002"
Starting Torque, Maximum	1.5 oz.-in.	1.3 oz.-in.
Running Torque, Maximum	1.2 oz.-in.	0.7 oz.-in.

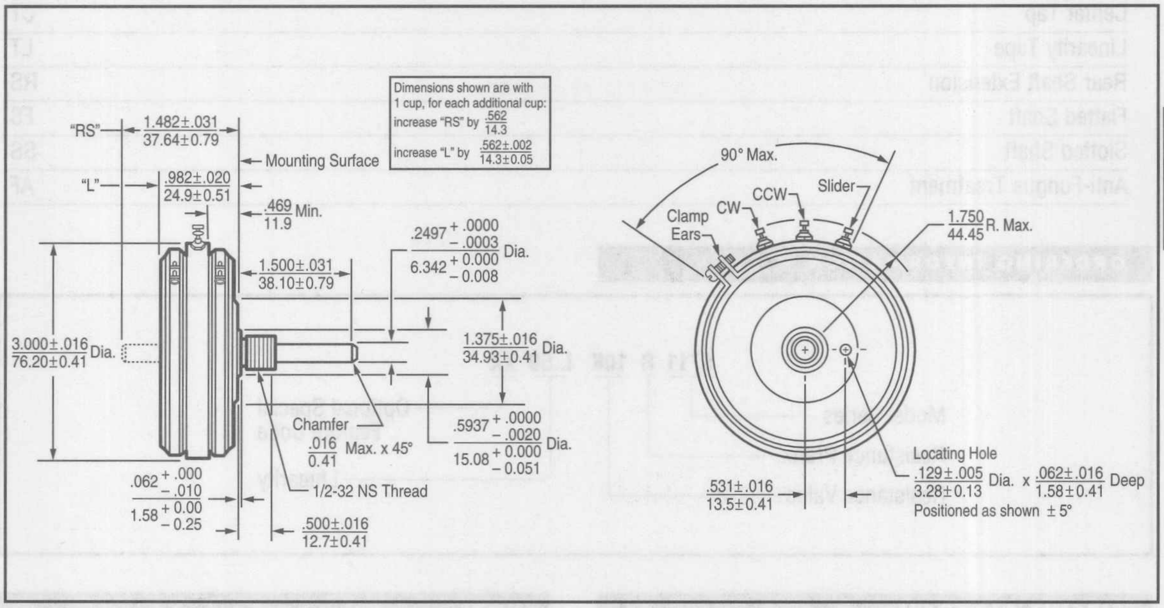
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
1K	0.062	±130 ppm/°C
2K	0.050	±130 ppm/°C
5K	0.038	±130 ppm/°C
10K	0.031	±130 ppm/°C
20K	0.027	±130 ppm/°C
50K	0.024	± 20 ppm/°C
100K	0.022	± 20 ppm/°C

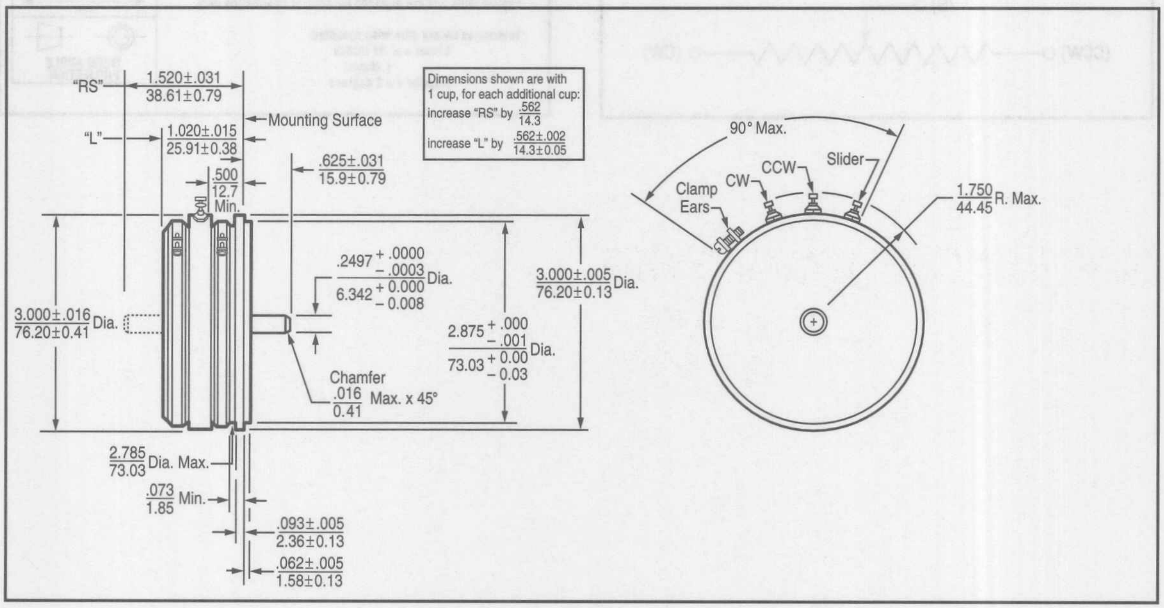
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

MODEL 5711



MODEL 5713



SPECIAL FEATURE CODES

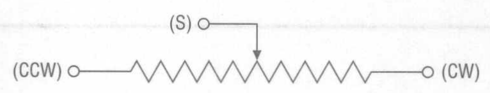
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Anti-Fungus Treatment	AF

ORDERING INFORMATION

5711 R 10K L.50 XX

- 5711 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- L.50 — Linearity
- XX — Optional Special Feature Code

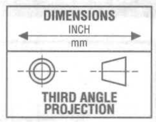
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

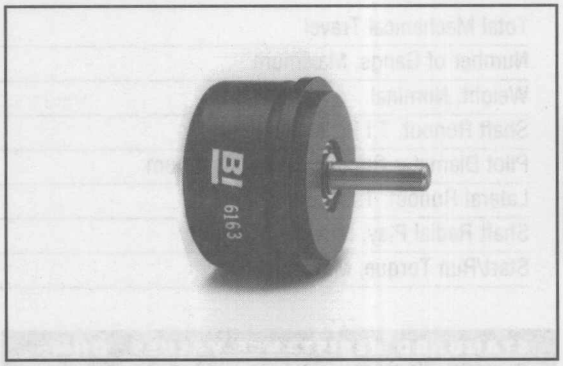
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL 6163

7/8" Diameter
Single Turn
Conductive Plastic
Precision Potentiometer / Position Sensor

Distributor Item



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ELECTRICAL

Resistance Range, Ohms	1K to 100K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity*	±1.0%
Minimum Practical Independent Linearity	±0.5%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	1.0 at 70°C derating to 0 at 125°C
Dielectric Strength	750V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	335°
Electrical Continuity Travel, Minimum	350°
End Voltage, Maximum	0.5% of Input Voltage
Resolution	Essentially infinite
Temperature Coefficient**	–800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ±100ppm/°C.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (10% ΔR)
High Temperature Exposure	1,000 hours at 125°C (0.5% ΔR)
Rotational Life	25 mil. shaft rev.
Rotational Load Life	5 mil. shaft rev. at rated wattage at 70°C (10% ΔR)

Specifications subject to change without notice.

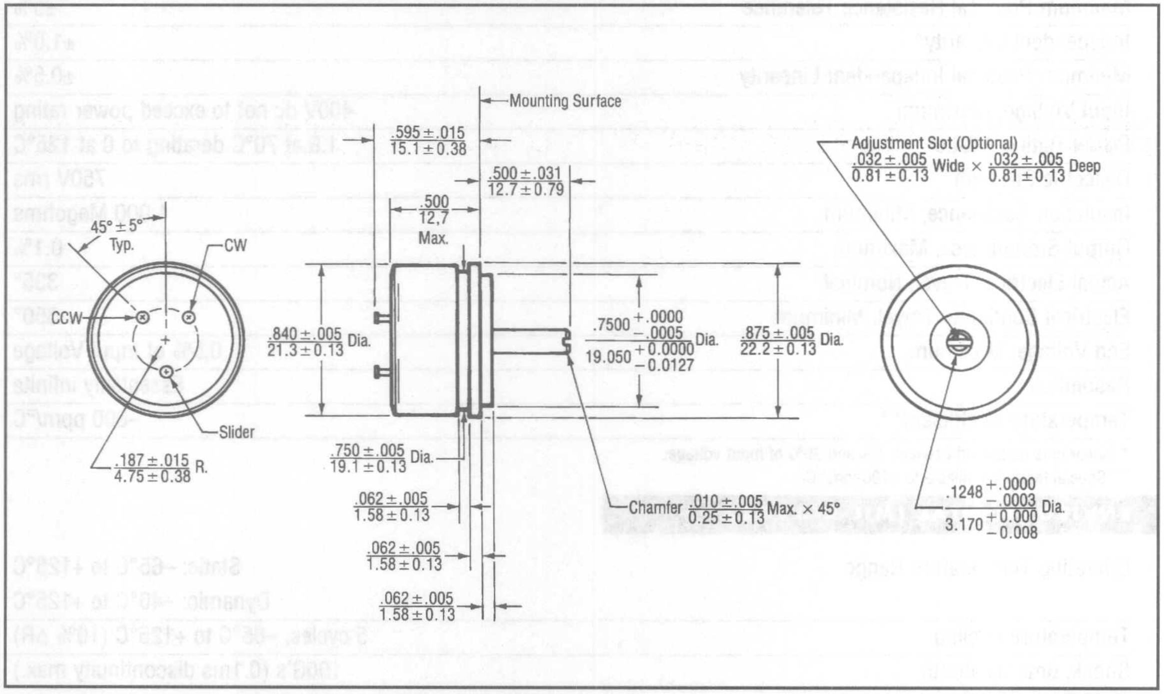
MECHANICAL

Total Mechanical Travel	360° continuous
Number of Gangs, Maximum	1
Weight, Nominal	0.46 oz.
Shaft Runout, T.I.R., Maximum	.003”
Pilot Diameter Runout, T.I.R., Maximum	.003”
Lateral Runout, T.I.R., Maximum	.003”
Shaft Radial Play, Maximum	.005”
Start/Run Torque, Maximum	0.5 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K

OUTLINE DIMENSIONS



METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

SPECIAL FEATURE CODES

Linearity Tape	LT
Flatted Shaft	FS
Slotted Shaft	SS

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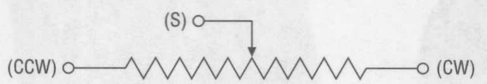
ORDERING INFORMATION

6163 R 10K T5 L 1.0 XX

- Model Series — 6163
- Resistance Prefix — R
- Resistance Value — 10K
- Optional Non-Standard Tolerance — T5
- Linearity — L 1.0
- Optional Special Feature Code — XX

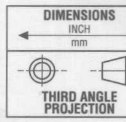
CIRCUIT DIAGRAM



NOTES

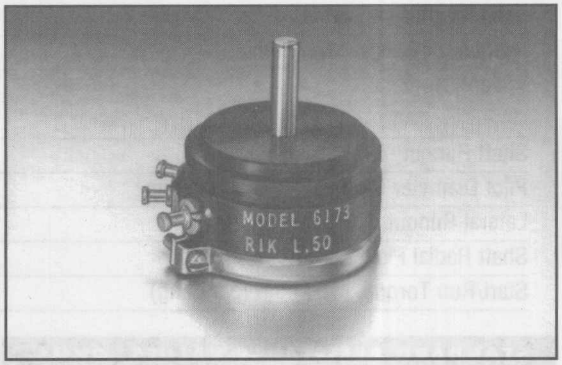
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL 6173

7/8" Diameter
Single Turn
Conductive Plastic
Precision Potentiometer / Position Sensor



ELECTRICAL

Resistance Range, Ohms	1K to 100K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity*	±0.5%
Minimum Practical Independent Linearity	±0.25%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	1.0 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	335°
Electrical Continuity Travel, Minimum	346°
Tap Tolerance	0.5% of input voltage
End Voltage, Maximum	0.5% of Input Voltage
Resolution	Essentially infinite
Temperature Coefficient**	–800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ±100ppm/°C.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 500 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (10% ΔR)
High Temperature Exposure	1,000 hours at 125°C (0.5% ΔR)
Rotational Life	25 mil. shaft rev.
Rotational Load Life	5 mil. shaft rev. + 900 hrs. at rated wattage at 70°C (10% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	360° continuous
Number of Gangs, Maximum	4
Weight, Nominal	0.92 oz. Single gang 0.6 oz. Each added gang
Shaft Runout, T.I.R., Maximum	.001"
Pilot Diameter Runout, T.I.R., Maximum	.001"
Lateral Runout, T.I.R., Maximum	.002"
Shaft Radial Play, Maximum	.001"
Start/Run Torque, Maximum (per gang)	0.5 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K

SPECIAL FEATURE CODES

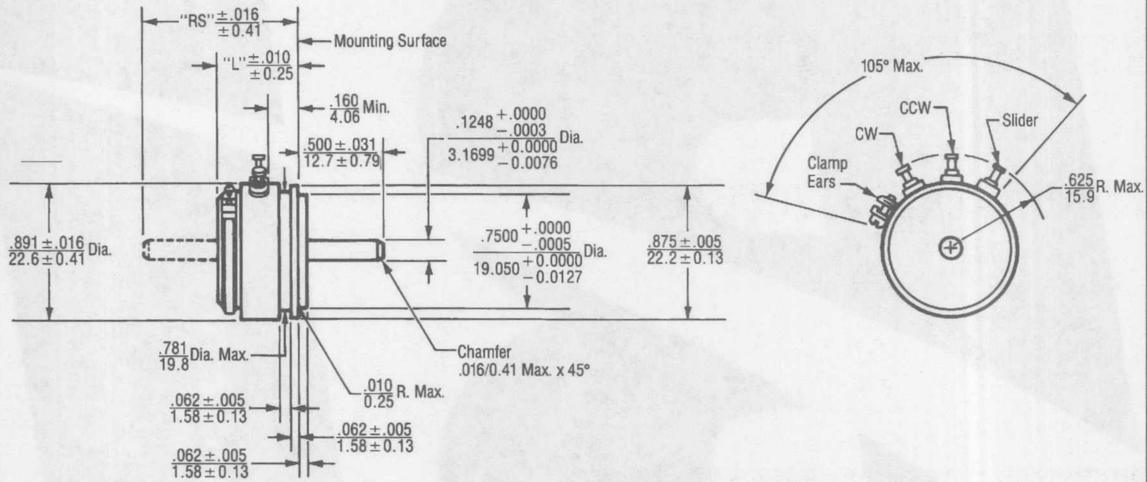
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Additional Gangs	2G or 3G or 4G

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

OUTLINE DIMENSIONS

Dim. "L"	Dim. "RS"	No.of Gangs
.500 / 12.7	1.000 / 25.40	1
.850 / 21.9	1.350 / 34.29	2
1.200 / 30.48	1.700 / 43.18	3
1.550 / 39.37	2.050 / 52.07	4

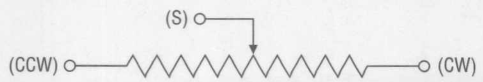


ORDERING INFORMATION

6173 R 10K T5 L .5 XX

- 6173 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L .5 — Linearity
- XX — Optional Special Feature Code

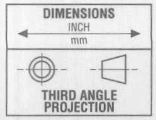
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

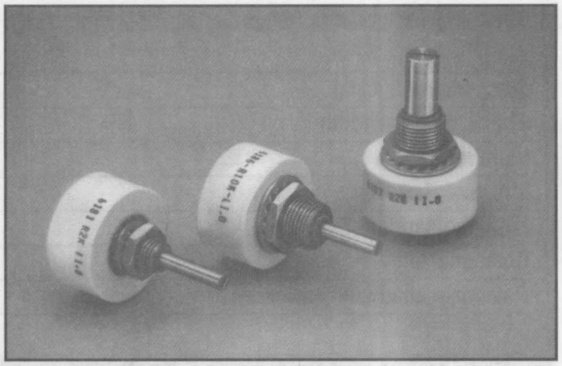
Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 6180

Distributor Item

7/8" Diameter
Single Turn
Conductive Plastic
Precision Potentiometer / Position Sensor



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MODEL STYLES

6181	1/8" Shaft, 1/4" Bushing
6186	1/8" Shaft, 3/8" Bushing
6187	1/4" Shaft, 3/8" Bushing

ELECTRICAL

Resistance Range, Ohms	1K to 100K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity *	±1.0%
Minimum Practical Independent Linearity	±0.5%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	1.0 at 70°C derating to 0 at 125°C
Dielectric Strength	750V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	340° (300° with stop feature)
Electrical Continuity Travel, Nominal	350° (320° with stop feature)
End Voltage, Maximum	0.5% of input voltage
Resolution	Essentially Infinite
Temperature Coefficient**	-800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ±100ppm/°C.
Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (25% ΔR)
High Temperature Exposure	1,000 hours at 125°C (0.5% ΔR)
Rotational Life	5 mil. shaft rev.
Rotational Load Life	5 mil. shaft rev. (10% ΔR)

MECHANICAL

Total Mechanical Travel	360° (320° ±3° with stop feature)
Number of Gangs, Maximum	1
Weight, Nominal (single gang)	0.53 oz.
Backlash, Maximum	1°
Static Stop Strength	40 oz.-in.
Panel Nut Tightening Torque, Maximum	25 lb.-in.
Start/Run Torque, Maximum	1.0 oz.-in.

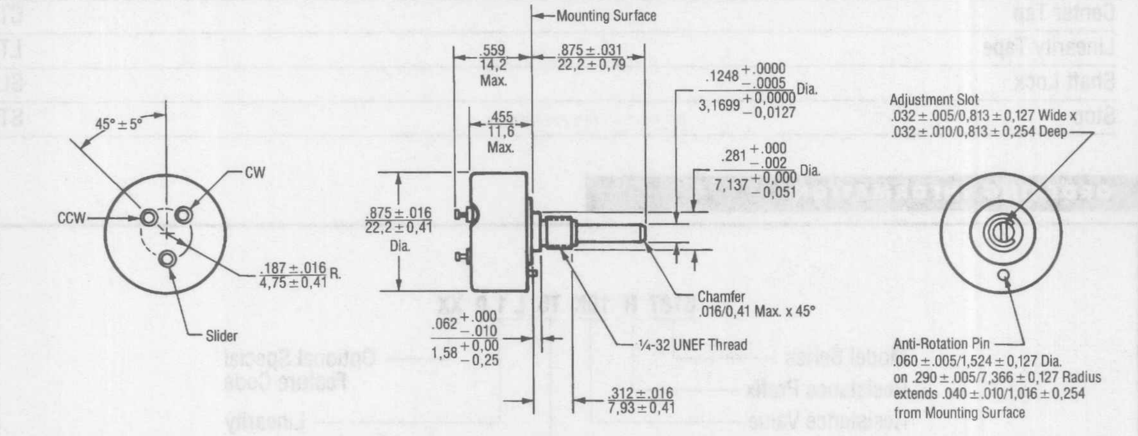
STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K

METRIC CONVERSIONS

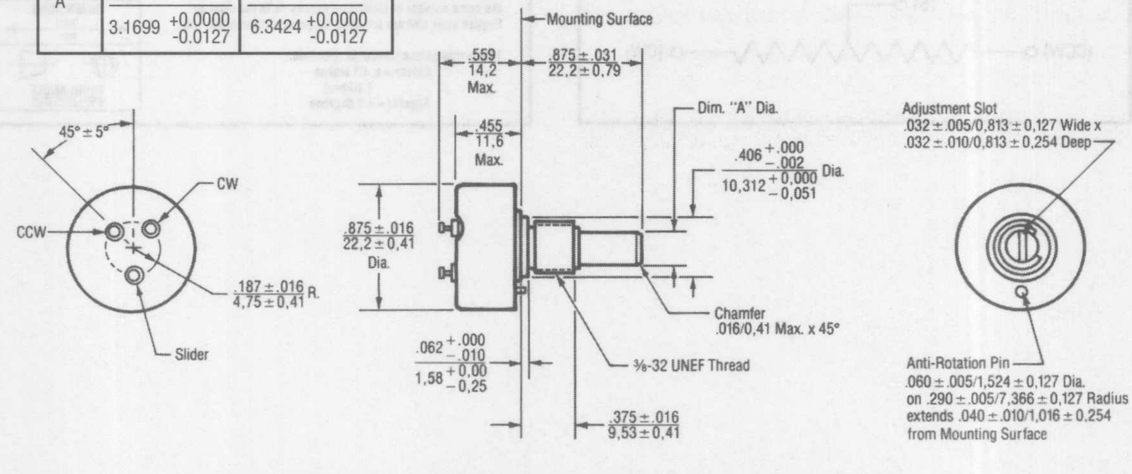
1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

MODEL 6181



MODEL 6186 & 6187

Dim.	Model 6186	Model 6187
A	.1248 +.0000 -.0005	.2497 +.0000 -.0005
	3.1699 +0.0000 -0.0127	6.3424 +0.0000 -0.0127



SPECIAL FEATURE CODES

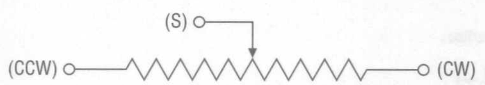
Center Tap	CT
Linearity Tape	LT
Shaft Lock	SL
Stop	ST

ORDERING INFORMATION

6187 R 10K T5 L 1.0 XX

- Model Series — 6187
- Resistance Prefix — R
- Resistance Value — 10K
- Optional Non-Standard Tolerance — T5
- Linearity — L 1.0
- Optional Special Feature Code — XX

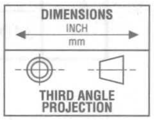
CIRCUIT DIAGRAM



NOTES

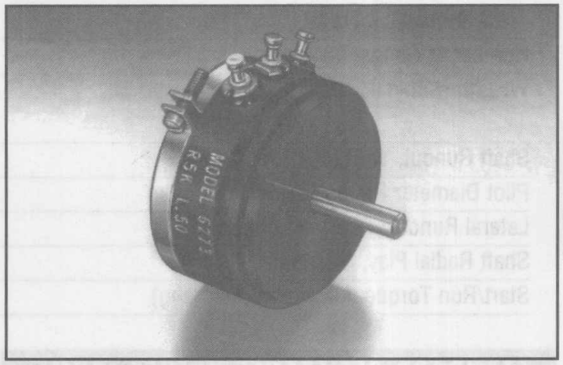
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL 6273

1-1/16" Diameter Single Turn Conductive Plastic Precision Potentiometer / Position Sensor



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ELECTRICAL

Resistance Range, Ohms	1K to 900K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity*	±0.5%
Minimum Practical Independent Linearity	±0.15%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	1.5 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	340°
Electrical Continuity Travel, Minimum	346°
Tap Tolerance	0.5% of input voltage
End Voltage, Maximum	0.5% of input voltage
Resolution	Essentially infinite
Temperature Coefficient**	–800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ±100ppm/°C.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (10% ΔR)
High Temperature Exposure	1,000 hours at 125°C (0.5% ΔR)
Rotational Life	25 mil. shaft rev.
Rotational Load Life	5 mil. shaft rev. at rated wattage at 70°C (10% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	360° continuous
Number of Gangs, Maximum	4
Weight, Nominal	1.0 oz. Single gang 0.7 oz. Each added gang
Shaft Runout, T.I.R., Maximum	.001"
Pilot Diameter Runout, T.I.R., Maximum	.001"
Lateral Runout, T.I.R., Maximum	.002"
Shaft Radial Play, Maximum	.001"
Start/Run Torque, Maximum (per gang)	0.5 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K

SPECIAL FEATURE CODES

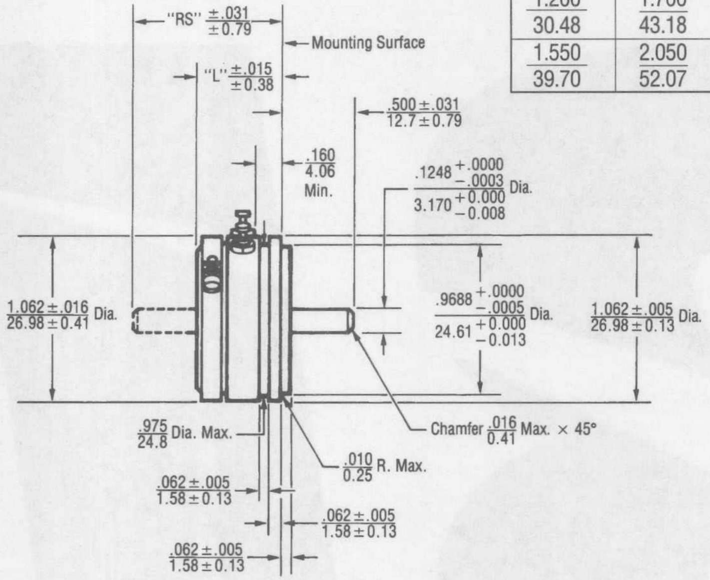
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Additional Gangs	2G or 3G or 4G

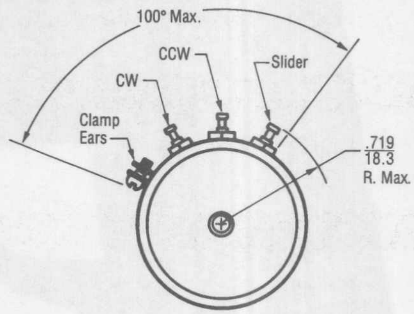
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

OUTLINE DIMENSIONS

Dim. "L"	Dim. "RS"	No.of Gangs
.500 / 12.7	1.000 / 25.40	1
.850 / 21.59	1.350 / 34.29	2
1.200 / 30.48	1.700 / 43.18	3
1.550 / 39.70	2.050 / 52.07	4



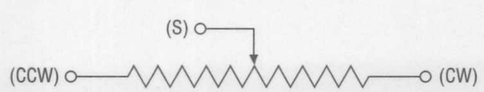


ORDERING INFORMATION

6273 R 10K T5 L.5 XX

- 6273 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L.5 — Linearity
- XX — Optional Special Feature Code

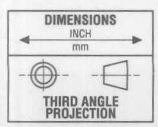
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 6370

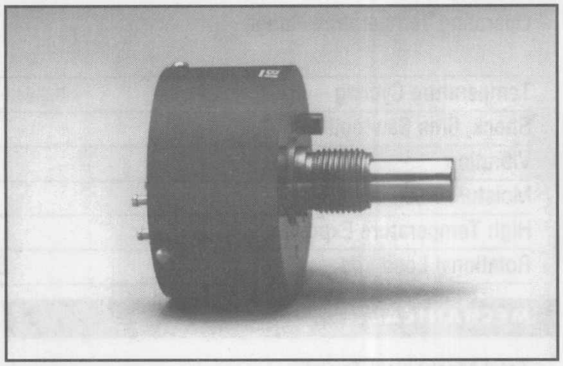
1-5/16" Diameter

Single Turn

Conductive Plastic

Precision Potentiometer /

Position Sensor



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FEATURES

- Anodized Aluminum Housing
- Front and Rear Ball Bearings

MODEL STYLES

6371	1/4" Shaft, 3/8" Bushing
6373	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	1K to 300K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity*	±0.5%
Minimum Practical Independent Linearity	±0.1%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	2.0 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	348°
Electrical Continuity Travel, Minimum	350°
End Voltage, Maximum	0.35% of Input Voltage
Tap Tolerance	0.5% of Input Voltage
Resolution	Essentially infinite
Temperature Coefficient**	–800 ppm/°C

* Linearity is measured between 1% and 99% of input voltage.
** Special tempco available to ±100ppm/°C.
Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (10% ΔR)
High Temperature Exposure	1,000 hours at 125°C (0.5% ΔR)
Rotational Load Life	5 mil. shaft rev. +900 hrs. at rated wattage at 70°C (10% ΔR)

MECHANICAL

Total Mechanical Travel	360° continuous
Number of Gangs, Maximum	1
Weight, Nominal	2.0 oz.
Shaft Runout, T.I.R., Maximum	.001"
Pilot Diameter Runout, T.I.R., Maximum	.0015"
Lateral Runout, T.I.R., Maximum	.002"
Shaft Radial Play, Maximum	.002"
Start/Run Torque, Maximum	0.7 / 0.5 oz.-in.

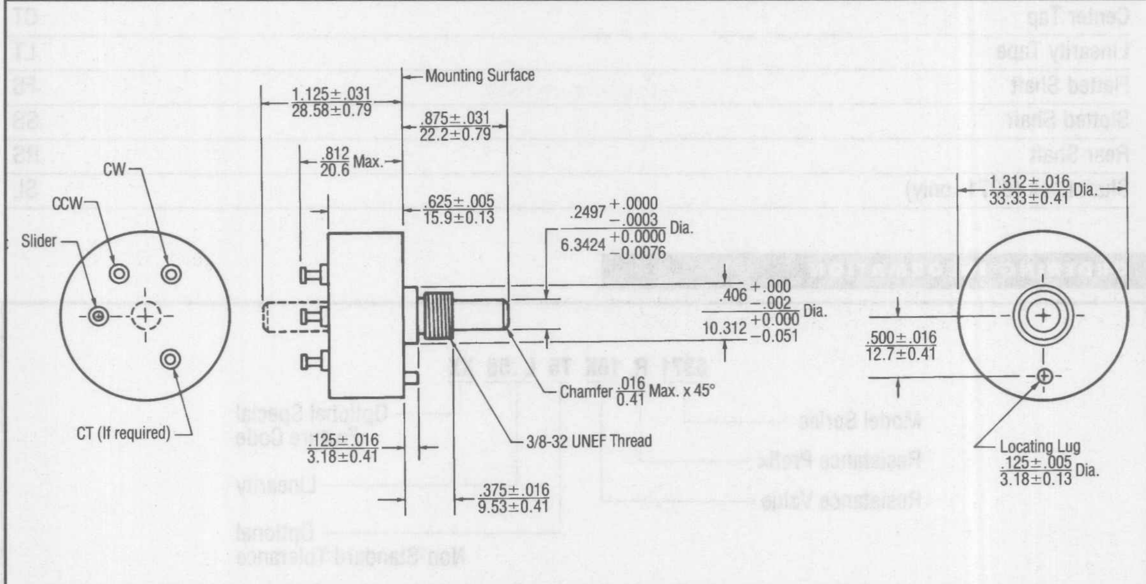
STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K

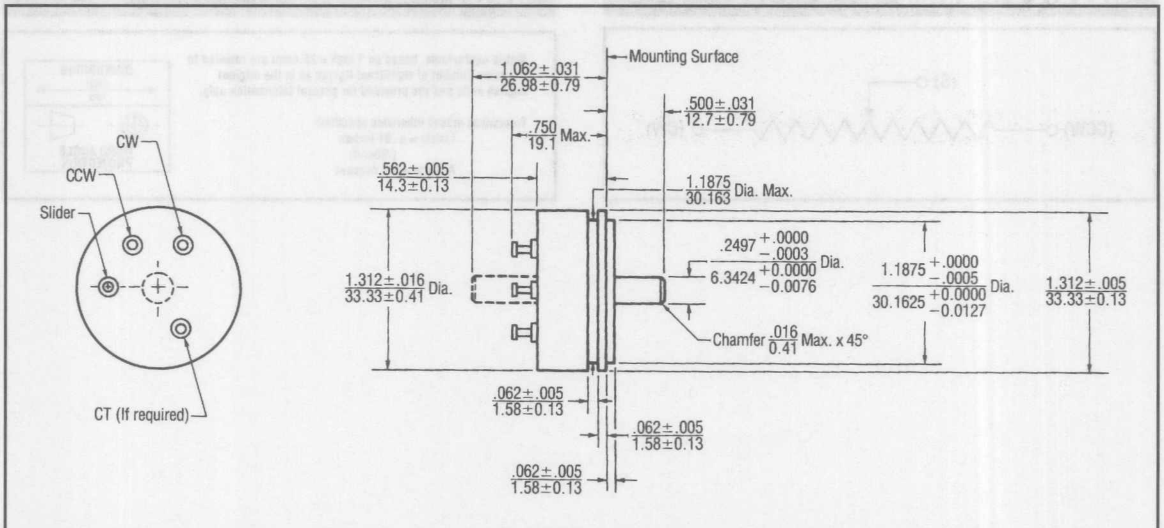
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

MODEL 6371



MODEL 6373



SPECIAL FEATURE CODES

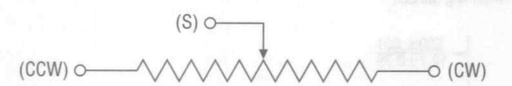
Center Tap	CT
Linearity Tape	LT
Flatted Shaft	FS
Slotted Shaft	SS
Rear Shaft	RS
Shaft Lock (6371 only)	SL

ORDERING INFORMATION

6371 R 10K T5 L .50 XX

- 6371 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L .50 — Linearity
- XX — Optional Special Feature Code

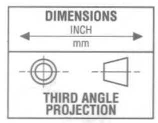
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



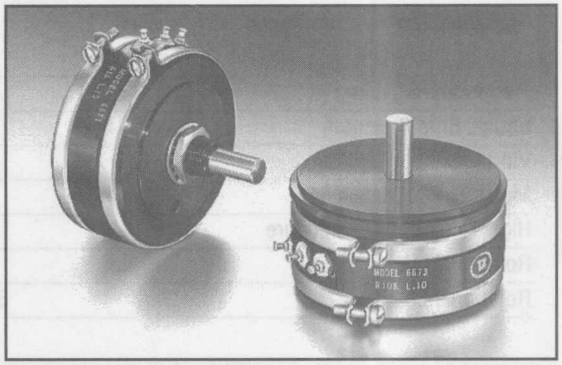
MODEL SERIES 6670

2" Diameter

Single Turn

Conductive Plastic

Precision Potentiometer / Position Sensor



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MODEL STYLES

6671	1/4" Shaft, 3/8" Bushing
6673	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	1K to 300K
Standard Resistance Tolerance*	±10%
Minimum Practical Resistance Tolerance	±3%
Independent Linearity**	±0.25%
Minimum Practical Independent Linearity	±0.1%
Input Voltage, Maximum	400V dc not to exceed power rating
Power Rating, Watts	3.5 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.1%
Actual Electrical Travel, Nominal	350°
Electrical Continuity Travel, Minimum	354°
Tap Tolerance	0.5% of input voltage
End Voltage, Maximum	Within standard linearity tolerance, not less than .25%
Resolution	Essentially infinite
Temperature Coefficient***	–800 ppm/°C

* Tighter tolerances available.
** Linearity is measured between 1% and 99% of input voltage.
*** Special tempco available to ±100ppm/°C.
Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (10% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (10% ΔR)
High Temperature Exposure	1,000 hours at 125°C (0.5% ΔR)
Rotational Life	25 mil. shaft rev.
Rotational Load Life	5 mil. shaft rev. + 900 hrs. at rated wattage at 70°C (10% ΔR)

MECHANICAL

Total Mechanical Travel	360° continuous
Number of Gangs, Maximum	4
Weight, Nominal	4.0 oz. Single gang 1.5 oz. Each added gang
Shaft Runout, T.I.R., Maximum	.001"
Pilot Diameter Runout, T.I.R., Maximum	.0015"
Lateral Runout, T.I.R., Maximum	.005"
Shaft Radial Play, Maximum	.002"
Start/Run Torque, Maximum (per gang)	1.5 / 1.0 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K

SPECIAL FEATURE CODES

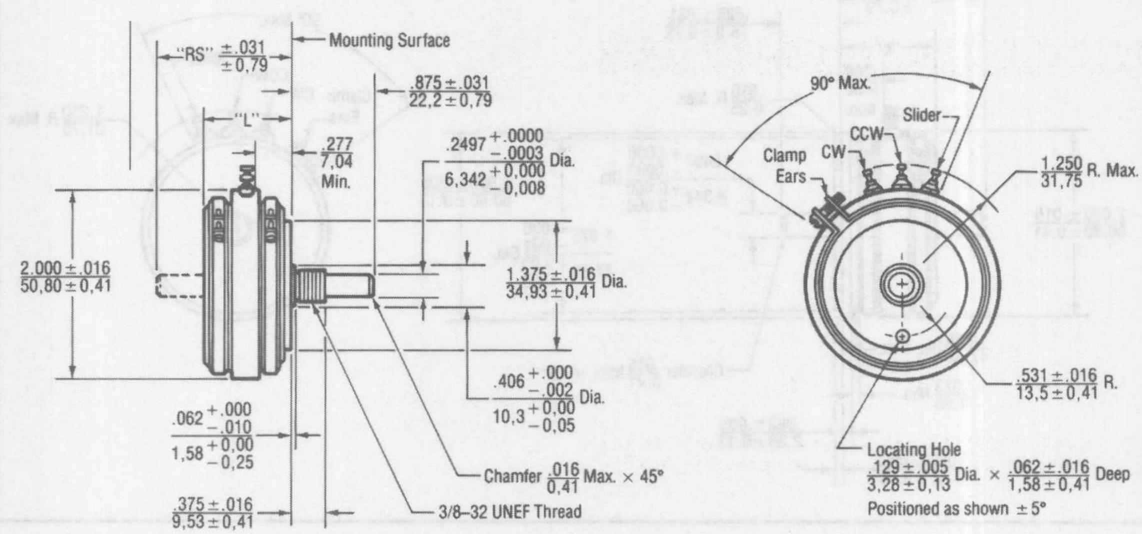
Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock (6671 only)	SL
Additional Gangs	2G or 3G or 4G

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

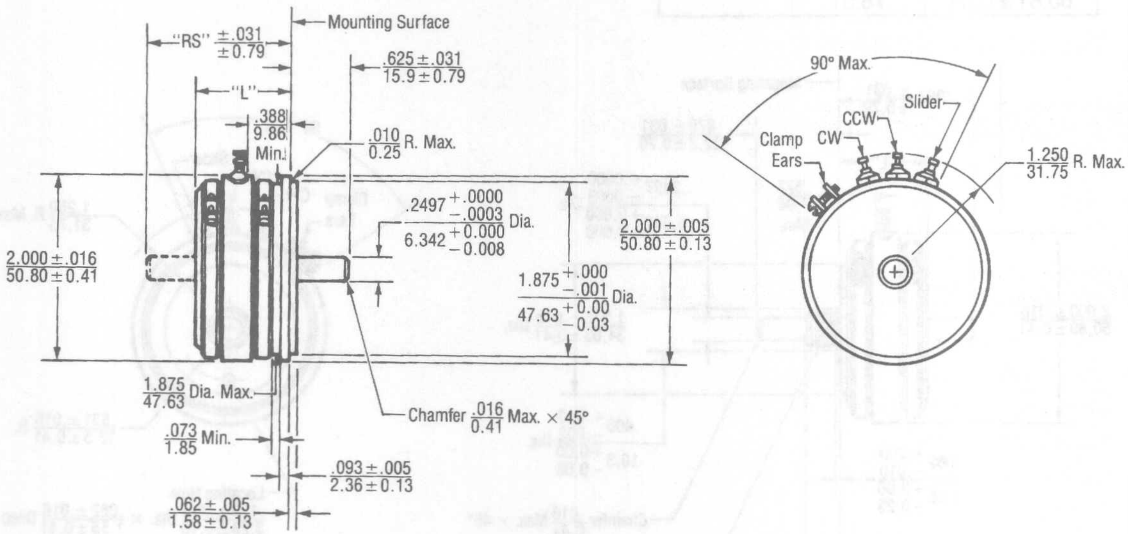
MODEL 6671 (BUSHING MOUNT WITH BALL BEARING)

Dim. "L"	Dim. "RS"	No.of Gangs
.905 ± .020 22,9 ± 0,51	1.405 35,69	1
1.467 ± 0.22 37,26 ± 0,56	1.967 49,96	2
2.029 ± 0.24 51,54 ± 0,61	2.529 64,24	3
2.591 ± 0.26 65,81 ± 0,66	3.091 78,51	4



MODEL 6673 (SERVO MOUNT WITH BALL BEARING)

Dim. "L"	Dim. "RS"	No.of Gangs
1.020 ± .015 25,91 ± 0,38	1.520 38,61	1
1.582 ± 0.17 40,18 ± 0,43	2.082 52,88	2
2.144 ± 0.19 54,46 ± 0,48	2.644 67,16	3
2.706 ± 0.21 68,73 ± 0,53	3.206 81,43	4

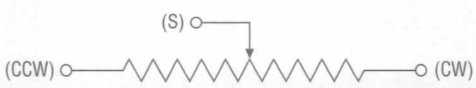


ORDERING INFORMATION

6671 R 10K T5 L .25 XX

- 6671 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L .25 — Linearity
- XX — Optional Special Feature Code

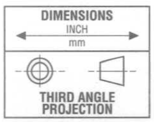
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 7200

7/8" Diameter

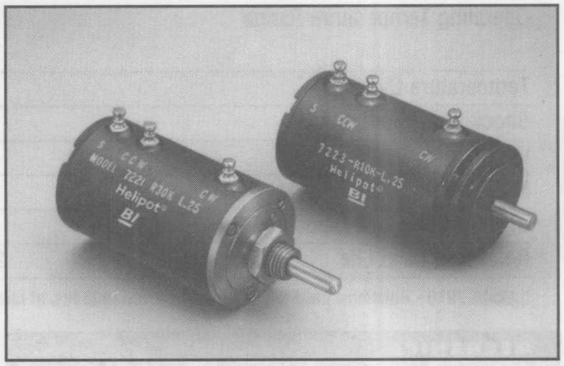
10-Turn

Wirewound

Precision Potentiometer/

Position Sensor

Distributor Item



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FEATURES

7216, 7221	Bushing Mount, Sleeve Bearing
7223	Servo Mount, Ball Bearing

ELECTRICAL

Resistance Range, Ohms	10 to 125K
Standard Resistance Tolerance	±3%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.25%
Minimum Practical Independent Linearity	±0.25%, ≤ 20 Ohms ±0.15%, 21-49 Ohms ±0.10%, 50-99 Ohms ±0.075%, 100-999 Ohms ±0.05%, ≥ 1K Ohms
Power Rating, Watts	2.0 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	3600° + 10° − 0°, > 25 Ohms 3600° + 10° − 5°, ≤ 25 Ohms
Tap Tolerance	±5°, ≤20 Ohms ±3°, 21-49 Ohms ±2°, ≥50 Ohms
End Voltage, Maximum (% of input voltage)	0.5%, <100 Ohms 0.25%, ≥100 Ohms

This model available in a hybrid version – contact factory for details.
Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-39023)

Operating Temperature Range	Static: –65°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	50G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	2 mil. shaft rev. + 900 hrs. at rated wattage at 70°C (5% ΔR)*

* Model 7216 - Rotational Load Life = 1 mil. shaft rev.+900 hrs. at rated wattage at 70°C (5% ΔR)

MECHANICAL

Total Mechanical Travel	3600° + 10° – 0°
Number of Gangs, Maximum	2
Weight, Nominal (single gang)	1.25 oz.
Static Stop Strength	128 oz.-in.
Backlash, Maximum	1.5°

	7216	7221	7223
Panel Nut Tightening Torque, Maximum	25 lb.-in.	25 lb.-in.	N/A
Shaft End Play, Maximum	.0085"	.005"	.005"
Shaft Runout, T.I.R., Maximum	.001"	.001"	.001"
Pilot Diameter Runout, T.I.R., Maximum	.001"	.001"	.0015"
Lateral Runout, T.I.R., Maximum	.003"	.003"	.003"
Shaft Radial Play, Maximum	.003"	.003"	.002"
Start/Run Torque, Maximum (per gang)	0.6 oz.-in / 0.5 oz.-in.		

STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
10	0.083	+ 800 ppm/°C **
25	0.055	+ 800 ppm/°C **
50	0.048	+ 800 ppm/°C **
100	0.040	+ 800 ppm/°C **
200	0.033	+ 800 ppm/°C **
500	0.031	± 20 ppm/°C
1K	0.028	± 20 ppm/°C
2K	0.025	± 20 ppm/°C
5K	0.020	+ 130 ppm/°C **
10K	0.018	+ 130 ppm/°C **
20K	0.016	+ 130 ppm/°C **
50K	0.012	± 20 ppm/°C
100K	0.011	± 20 ppm/°C

* * Lower tempco available as a special model.

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock (7216, 7221 only)	SL
Additional Gangs	2G

2

ORDERING INFORMATION

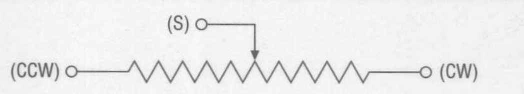
7216 R 10K T2 L .25 XX

- Model Series — 7216
- Resistance Prefix — R
- Resistance Value — 10K
- Optional Non-Standard Tolerance — T2
- Linearity — L .25
- Optional Special Feature Code — XX

MATCHING TURNS COUNTING DIALS

7216: 2606, 2606S, 2607, 2607S, 2626, 2627, 2646, 2646S, 2647, 2647S, 2157, 2167, RB
7221: RBJ, 2601, 2641

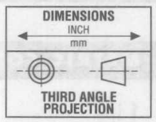
CIRCUIT DIAGRAM



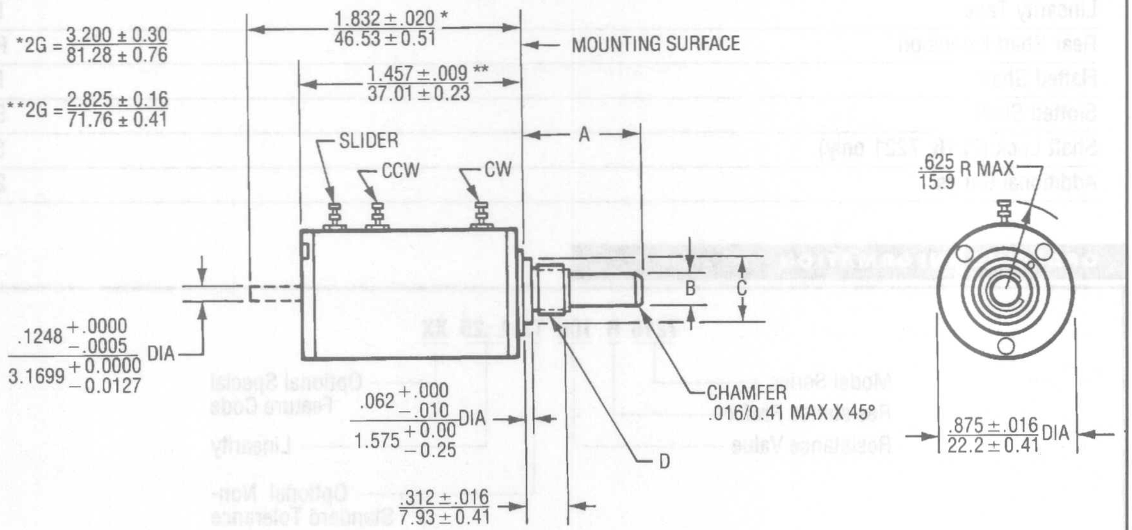
NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



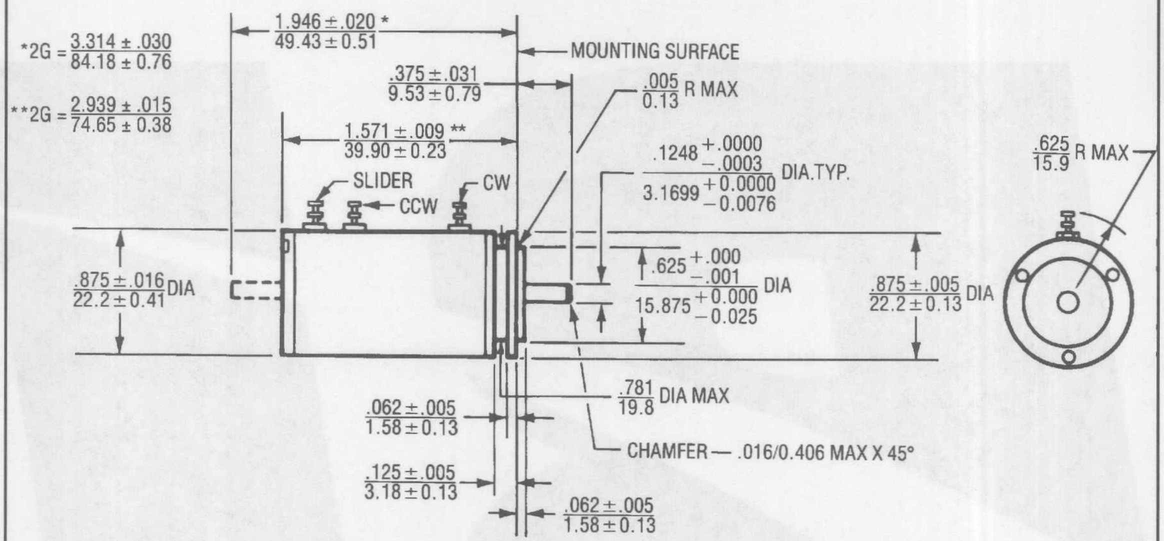
MODEL 7216 & 7221 (BUSHING MOUNT WITH SLEEVE BEARING)



DIM	7221	7216
A	.688 ± .031 / 17.475 ± 0.787	.812 ± .031 / 20.625 ± 0.787
B	.1248 +.0000 −.0003 / 3.1699 + 0.0000 − 0.0076 DIA.	.2500 +.0000 −.0005 / 6.3500 + 0.0000 − 0.0127 DIA.
C	.281 +.000 −.002 / 7.137 + 0.000 − 0.051 DIA.	.406 +.000 −.002 / 10.312 + 0.000 − 0.051 DIA.
D	1/4 - 32 UNEF THREAD	3/8 - 32 UNEF THREAD

METRIC CONVERSIONS

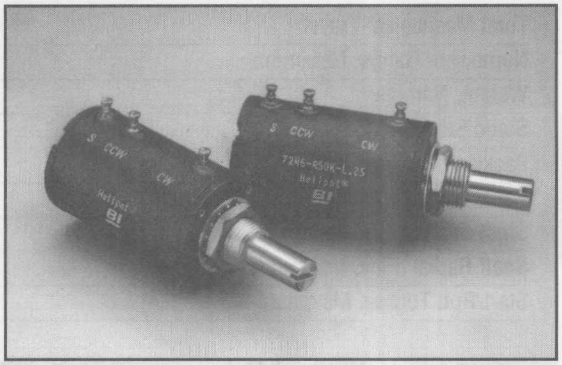
1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m


*2G = 3.314 ± .030 / 84.18 ± 0.76
**2G = 2.939 ± .015 / 74.65 ± 0.38
1.946 ± .020 * / 49.43 ± 0.51
MOUNTING SURFACE
.375 ± .031 / 9.53 ± 0.79
.005 / 0.13 R MAX
1.571 ± .009 ** / 39.90 ± 0.23
.1248 +.0000 −.0003 / 3.1699 +0.0000 −0.0076 DIA.TYP.
SLIDER
CW
CCW
.625 / 15.9 R MAX
.875 ± .016 / 22.2 ± 0.41 DIA
.625 +.000 −.001 / 15.875 +0.000 −0.025 DIA
.875 ± .005 / 22.2 ± 0.13 DIA
.781 / 19.8 DIA MAX
.062 ± .005 / 1.58 ± 0.13
CHAMFER — .016/0.406 MAX X 45°
.125 ± .005 / 3.18 ± 0.13
.062 ± .005 / 1.58 ± 0.13

MODEL 7246

7/8" Diameter
10-Turn
Wirewound
Precision Potentiometer

Distributor Item



2

ELECTRICAL

Resistance Range, Ohms	10 to 125K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±3%
Independent Linearity	±0.25%
Minimum Practical Independent Linearity	±0.25%, <100 Ohms ±0.15%, ≥ 100 Ohms
Power Rating, Watts	2.0 at 25°C derating to 0 at 85°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	3600° + 10° – 0°
Tap Tolerance	±5°, ≤20 Ohms ±3°, 21-50 Ohms ±2°, >50 Ohms
End Voltage, Maximum (% of input voltage)	0.5%, <100 Ohms 0.25%, ≥100 Ohms

This model available in a hybrid version – contact factory for details.

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	–25°C to +85°C
Temperature Cycling	5 cycles, –25°C to +85°C (10% ΔR)
Shock, 6ms Sawtooth	50G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (2% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (25% ΔR)
High Temperature Exposure	Mechanical Operation at 85°C (0.5% ΔR)
Rotational Load Life	1 mil. shaft rev. (10% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	3600° + 10° – 0°
Number of Gangs, Maximum	1
Weight, Nominal	1.25 oz.
Static Stop Strength	60 oz.-in.
Backlash, Maximum	2°
Panel Nut Tightening Torque, Maximum	25 lb.-in.
Shaft End Play, Maximum	.015"
Shaft Radial Play, Maximum	.005"
Start/Run Torque, Maximum	0.8 / 0.6 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

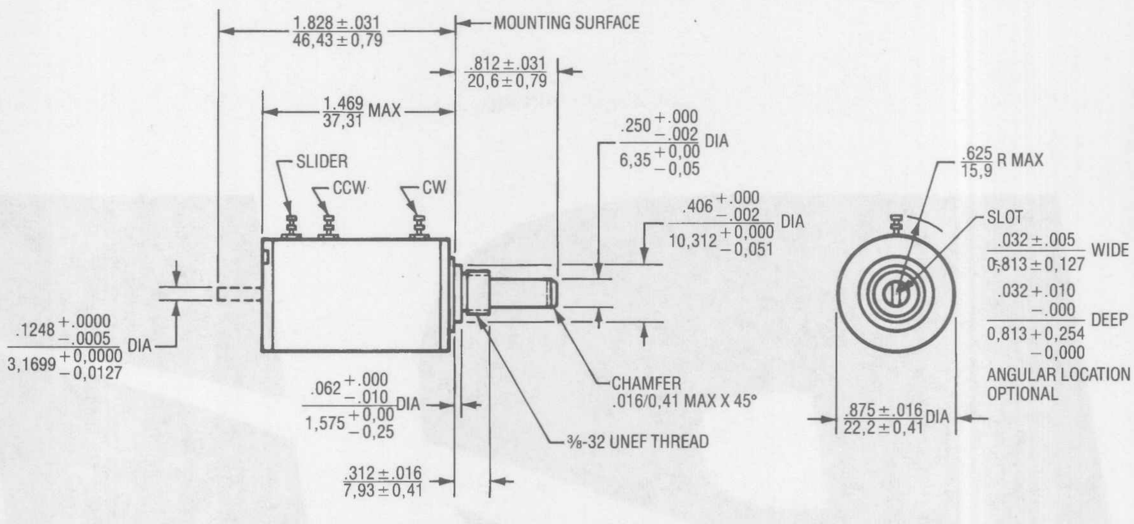
Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
10	0.083	+ 800 ppm/°C *
50	0.048	+ 800 ppm/°C *
100	0.040	+ 800 ppm/°C *
200	0.033	+ 800 ppm/°C *
500	0.031	±20 ppm/°C
1K	0.028	±20 ppm/°C
2K	0.025	±20 ppm/°C
5K	0.020	±130 ppm/°C *
10K	0.018	±130 ppm/°C *
20K	0.016	±130 ppm/°C *
50K	0.012	±20 ppm/°C
100K	0.011	±20 ppm/°C

* Lower tempco available as a special model.

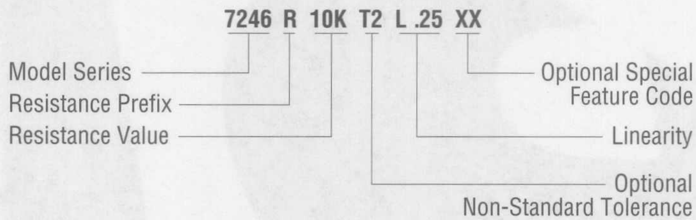
SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Shaft Lock	SL

OUTLINE DIMENSIONS



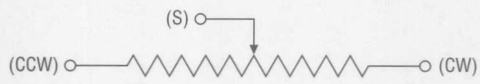
ORDERING INFORMATION



MATCHING TURNS COUNTING DIALS

2606, 2606S, 2607, 2607S, 2626, 2627, 2646, 2646S, 2647, 2647S, 2126, 2157, 2167, RB

CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

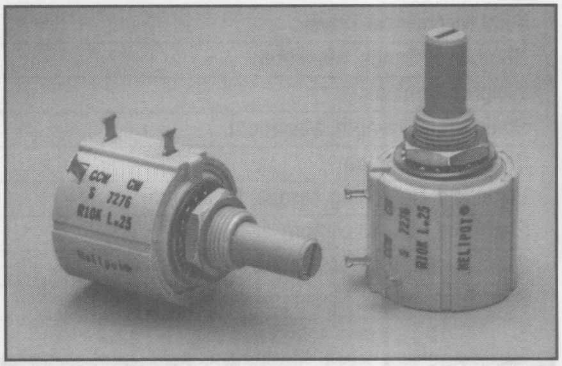
Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees

DIMENSIONS
INCH
mm
THIRD ANGLE PROJECTION

MODEL 7274, 7276

7/8" Diameter
Plastic 10–Turn
Wirewound
Precision Potentiometer

Distributor Item



2

MODEL STYLES

7274	6mm Shaft, 3/8" Bushing
7276	1/4" Shaft, 3/8" Bushing

ELECTRICAL

Resistance Range, Ohms	100 to 100K
Standard Resistance Tolerance	±5%
Independent Linearity	±0.25%
Power Rating, Watts	2.0 at 25°C derating to 0 at 105°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	3600° + 10° – 0°
Tap Tolerance	±3°
End Voltage, Maximum (% of input voltage)	0.25%

ENVIRONMENTAL (MIL-R-12534)

Operating Temperature Range	–25°C to +105°C
Temperature Cycling	5 cycles, –25°C to +105°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 105°C (5% ΔR)
Rotational Load Life	500K shaft rev. + 900 hrs. at rated wattage at 25°C (5%ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel	3600° + 15° – 0°
Number of Gangs, Maximum	1
Weight, Nominal	0.42 oz.
Static Stop Strength, Maximum	60 oz.-in.
Backlash, Maximum	2°
Panel Nut Tightening Torque, Maximum	8 lb.-in.
Shaft End Play, Maximum	.010"
Shaft Radial Play, Maximum	.010"
Start/Run Torque, Maximum	1.5 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
100	0.059	±20 ppm/°C
200	0.037	±20 ppm/°C
500	0.030	±20 ppm/°C
1K	0.024	±20 ppm/°C
2K	0.020	±20 ppm/°C
5K	0.018	±20 ppm/°C
10K	0.017	±20 ppm/°C
20K	0.016	±20 ppm/°C
50K	0.010	±20 ppm/°C
100K	0.009	±20 ppm/°C

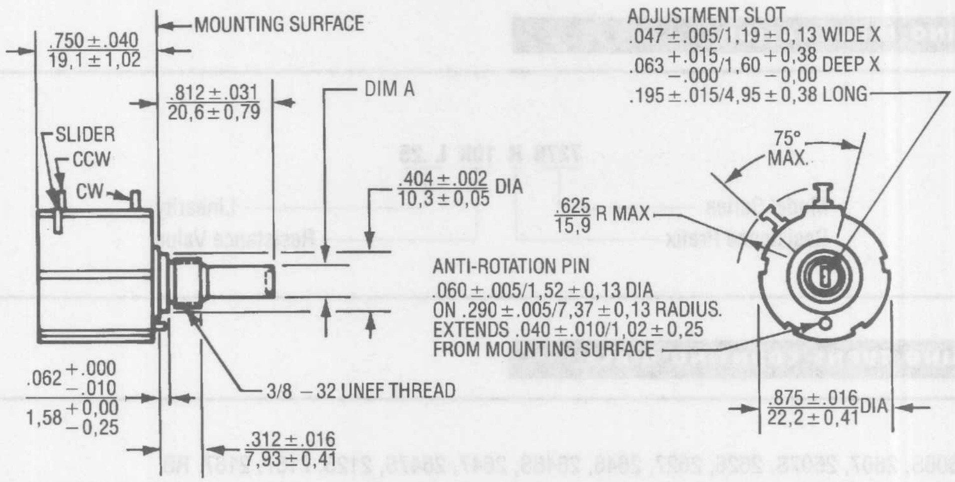
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

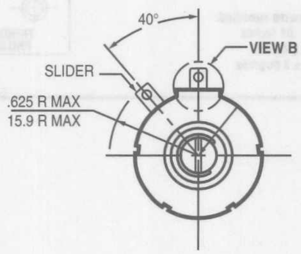
2

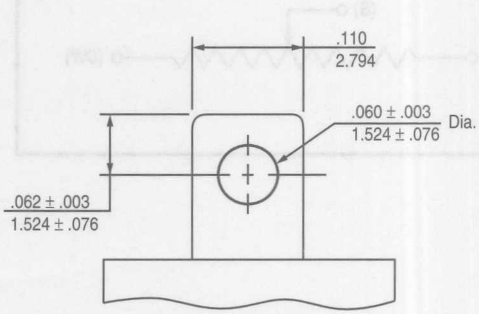
MODEL 7276

DIM	7274	7276
A	$.2362\ {}^{+.0000}_{-.0020}$ DIA. / $6{,}00\ {}^{+0{,}00}_{-0{,}05}$	$\frac{.249 \pm .001}{6.33 \pm 0.03}$ DIA.



OPTIONAL TERMINAL CONFIGURATION





Enlarged View B

Use Special Feature Code "FT" to order.

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Flatted Shaft	FS
Shaft Lock	SL
Gold Plated Solder Lug Terminals (see optional terminal configuration)	FT

ORDERING INFORMATION

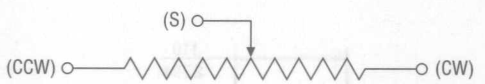
7276 R 10K L .25

- Model Series — 7276
- Resistance Prefix — R
- Resistance Value — 10K
- Linearity — L .25

MATCHING TURNS COUNTING DIALS

2606, 2606S, 2607, 2607S, 2626, 2627, 2646, 2646S, 2647, 2647S, 2126, 2157, 2167, RB

CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

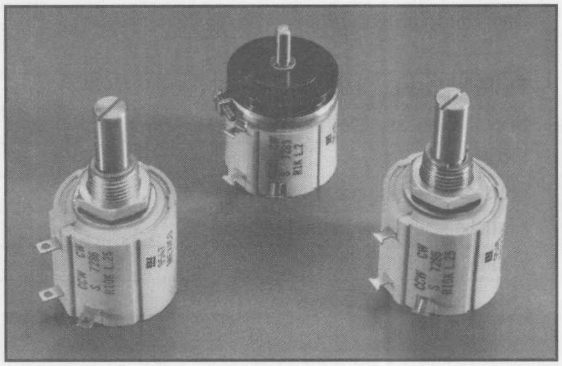
DIMENSIONS
INCH
mm

THIRD ANGLE PROJECTION

MODEL SERIES 7280

7/8" Diameter
10-Turn
Wirewound
Precision Potentiometer

Distributor Item



2

MODEL STYLES

7281	1/8" Shaft, 1/4" Bushing
7283	1/8" Shaft, Servo
7284	6mm Shaft, 3/8" Bushing
7286	1/4" Shaft, 3/8" Bushing

ELECTRICAL

Resistance Range, Ohms	100 to 100K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.25%
Minimum Practical Independent Linearity	±0.15%, < 300 Ohms ±0.075%, ≥ 300 Ohms
Power Rating, Watts	2.0 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	3600° + 10° − 0°, > 100 Ohms 3600° + 10° − 5°, ≤ 100 Ohms
Tap Tolerance	±3°
End Voltage, Maximum	0.25% of input voltage

Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-12534)

Operating Temperature Range	Static: –55°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –55°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	1 mil. shaft rev. + 900 hrs. at rated wattage at 70°C (5% ΔR)

MECHANICAL

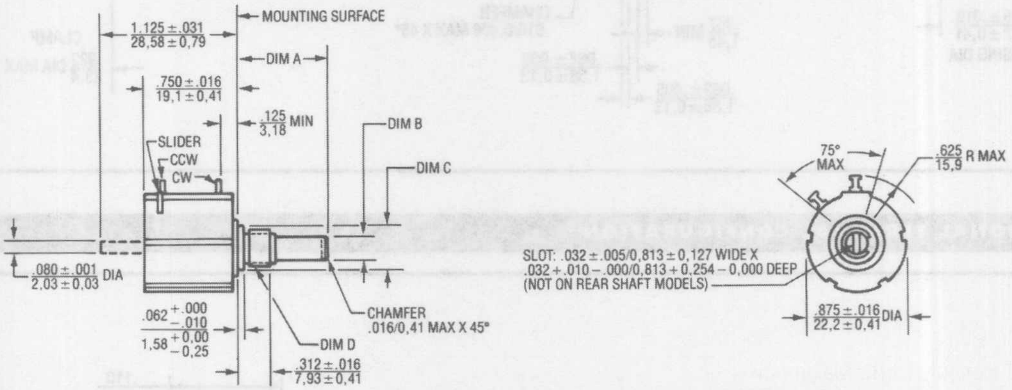
Total Mechanical Travel		3600° + 15° – 0°
Number of Gangs, Maximum		2
Weight, Nominal (single gang)		0.75 oz.
Backlash, Maximum		1°
	7281, 7284, 7286	**7283**
Static Stop Strength	60 oz.-in.	36 oz.-in.
Panel Nut Tightening Torque, Maximum	25 lb.-in.	N/A
Shaft End Play, Maximum	.010"	.005"
Shaft Runout, T.I.R., Maximum	.003"	.002"
Pilot Diameter Runout, T.I.R., Maximum	.004"	.002"
Lateral Runout, T.I.R., Maximum	.005"	.004"
Shaft Radial Play, Maximum	.003"	.002"
Start/Run Torque, Maximum (per gang)	0.8 oz.-in.	0.6 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

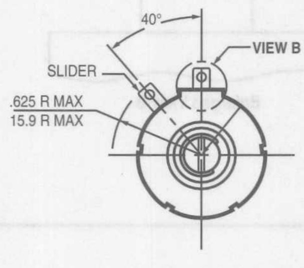
Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
100	0.059	±20 ppm/°C
200	0.037	±20 ppm/°C
500	0.030	±20 ppm/°C
1K	0.024	±20 ppm/°C
2K	0.020	±20 ppm/°C
5K	0.018	±20 ppm/°C
10K	0.017	±20 ppm/°C
20K	0.016	±20 ppm/°C
50K	0.010	±20 ppm/°C
100K	0.008	±20 ppm/°C

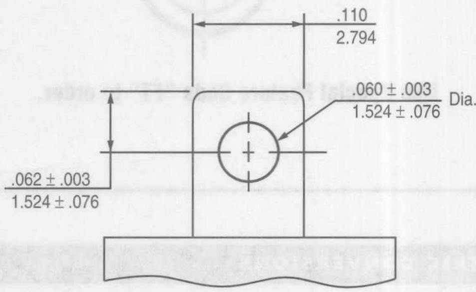
MODEL 7281, 7284 & 7286 (BUSHING MOUNT WITH SLEEVE BEARING)

DIM	7281	7284	7286
A	.688 ± .031 / 17,475 ± 0,787	.812 ± .031 / 20,625 ± 0,787	.812 ± .031 / 20,625 ± 0,787
B	.1248 +0.0000 -0.0003 / 3,1699 +0,0000 -0,0076 Dia.	.2362 +0.0000 -0.0005 / 6,0000 +0,0000 -0,0127 Dia.	.2500 +0.0000 -0.0005 / 6,3500 +0,0000 -0,0127 Dia.
C	.281 +0.000 -0.002 / 7,137 +0,000 -0,051 Dia.	.406 +0.000 -0.002 / 10,312 +0,000 -0,051 Dia.	.406 +0.000 -0.002 / 10,312 +0,000 -0,051 Dia.
D	1/4 - 32 UNEF Thread	3/8 - 32 UNEF Thread	3/8 - 32 UNEF Thread



OPTIONAL TERMINAL CONFIGURATION

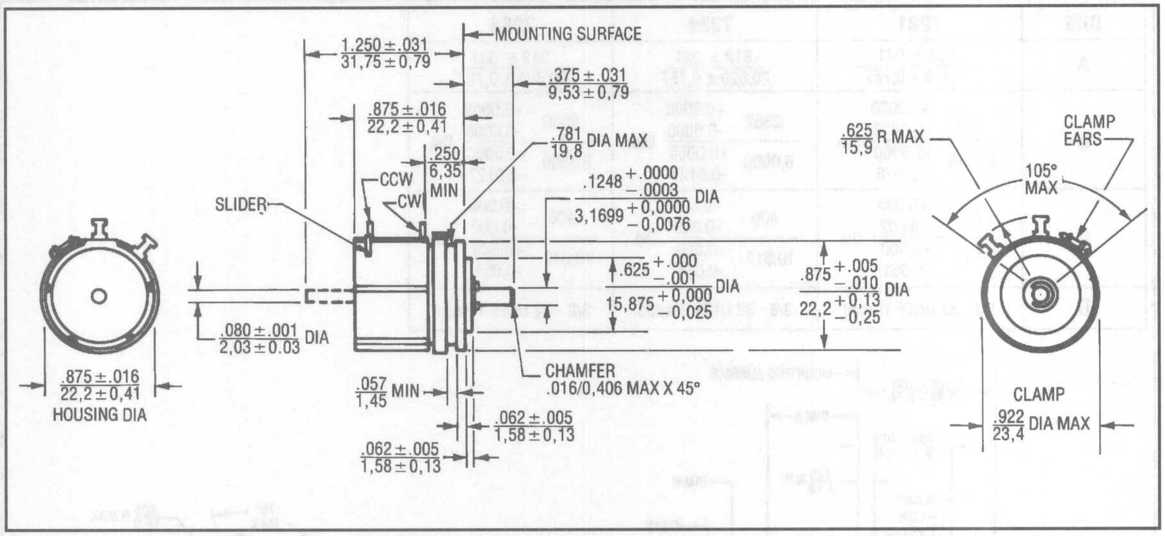




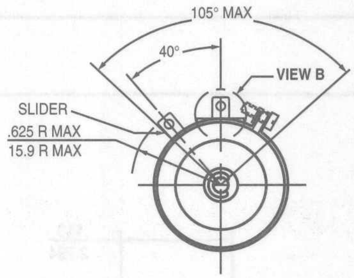
Use Special Feature Code "FT" to order.

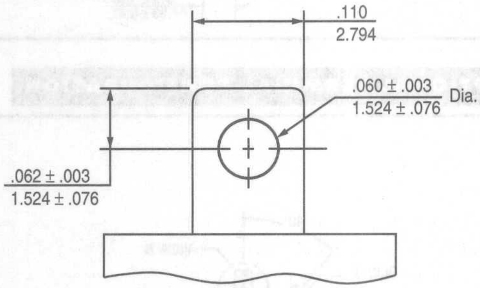
Enlarged View B

MODEL 7283 (SERVO MOUNT WITH BALL BEARING)



OPTIONAL TERMINAL CONFIGURATION





Enlarged View B

Use Special Feature Code "FT" to order.

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension (7283, 7286 single cup only)	RS
Flatted Shaft	FS
Slotted Shaft (Standard on single cup 7286 without RS)	SS
Shaft Lock (7281, 7286 only)	SL
High Torque, 2–6 oz.-in. (7286 only)	HT
Additional Gangs	2G
Gold Plated Solder Lug Terminals (See Optional Terminal Configuration)	FT

2

ORDERING INFORMATION

7286 R 10K T2 L .25 XX

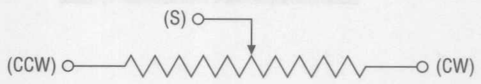
- 7286 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T2 — Optional Non-Standard Tolerance
- L .25 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

7281: RBJ, 2601, 2641

7286: 2606, 2607, 2626, 2627, 2646, 2647, 2157, 2126, 2167, 2606S, 2607S, 2646S, 2647S, RB

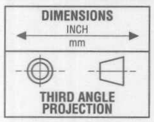
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 7380

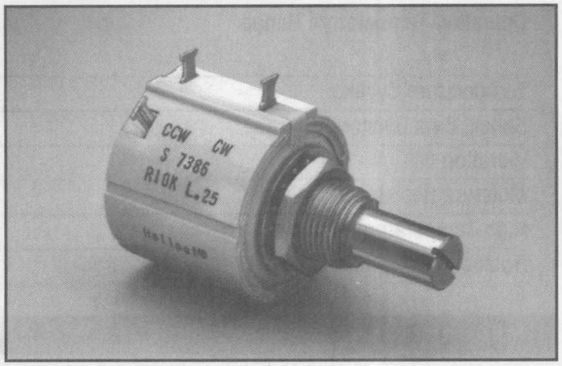
Distributor Item

7/8" Diameter

3–Turn

Wirewound

Precision Potentiometer



2

MODEL STYLES

7381	1/8" Shaft, 1/4" Bushing
7383	1/8" Shaft, Servo
7386	1/4" Shaft, 3/8" Bushing

ELECTRICAL

Resistance Range, Ohms	100 to 30K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.25%, ±0.50%
Minimum Practical Independent Linearity	±0.30%, < 500 Ohms ±0.20%, ≥ 500 Ohms
Power Rating, Watts	1.5 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	1080° + 10° – 0°, > 100 Ohms 1080° + 10° – 5°, ≤ 100 Ohms
Tap Tolerance	±3°
End Voltage, Maximum	0.25% of input voltage

Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-12534)

Operating Temperature Range	Static: –55°C to +125°C Dynamic: –40°C to +125°C
Temperature Cycling	5 cycles, –55°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	300K shaft rev. + 900 hrs. at rated wattage at 70°C (5% ΔR)

MECHANICAL

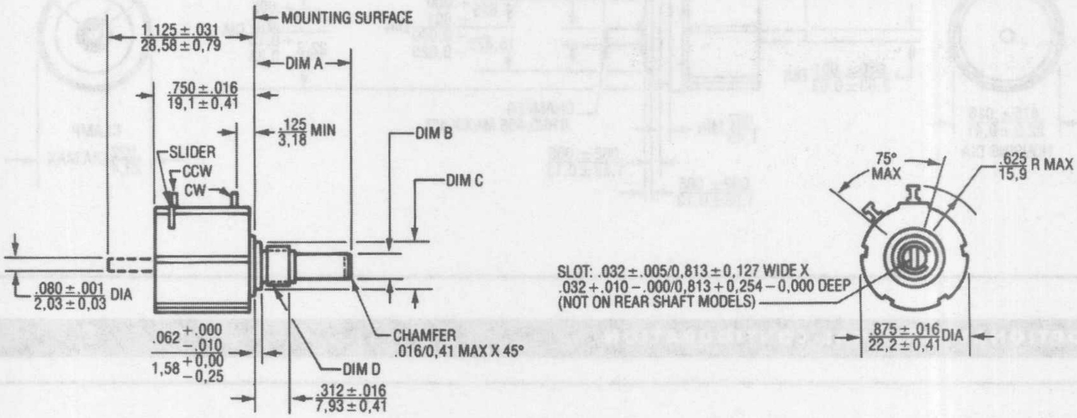
Total Mechanical Travel		1080° + 15° – 0°
Number of Gangs, Maximum		2
Weight, Nominal (single gang)		0.75 oz.
Backlash, Maximum		1°
	7381, 7386	**7383**
Static Stop Strength	60 oz.-in.	36 oz.-in.
Panel Nut Tightening Torque, Maximum	25 lb.-in.	N/A
Shaft End Play, Maximum	.010"	.005"
Shaft Runout, T.I.R., Maximum	.003"	.002"
Pilot Diameter Runout, T.I.R., Maximum	.004"	.002"
Lateral Runout, T.I.R., Maximum	.005"	.004"
Shaft Radial Play, Maximum	.003"	.002"
Start/Run Torque, Maximum (per gang)	1.2 oz.-in.	0.9 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

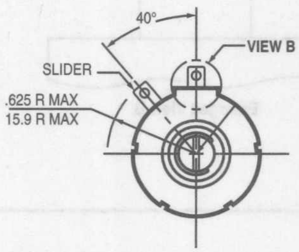
Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
100	0.059	±20 ppm/°C
200	0.037	±20 ppm/°C
500	0.030	±20 ppm/°C
1K	0.024	±20 ppm/°C
2K	0.020	±20 ppm/°C
5K	0.018	±20 ppm/°C
10K	0.017	±20 ppm/°C
20K	0.016	±20 ppm/°C

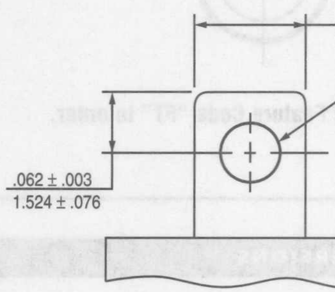
MODEL 7381 & 7386 (BUSHING MOUNT WITH SLEEVE BEARING)

DIM	7381	7386
A	.688 ± .031 / 17,475 ± 0,787	.812 ± .031 / 20,625 ± 0,787
B	$.1248^{+.0000}_{-.0003}$ / $3{,}1699^{+0{,}0000}_{-0{,}0076}$ DIA.	$.2500^{+.0000}_{-.0005}$ / $6{,}3500^{+0{,}0000}_{-0{,}0127}$ DIA.
C	$.281^{+.000}_{-.002}$ / $7{,}137^{+0{,}000}_{-0{,}051}$ DIA.	$.406^{+.000}_{-.002}$ / $10{,}312^{+0{,}000}_{-0{,}051}$ DIA.
D	1/4 - 32 UNEF THREAD	3/8 - 32 UNEF THREAD



OPTIONAL TERMINAL CONFIGURATION

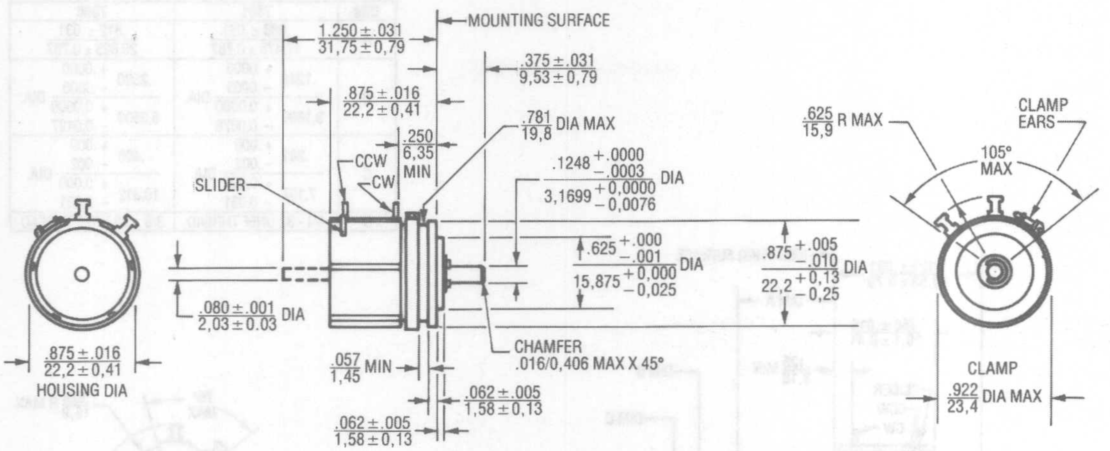




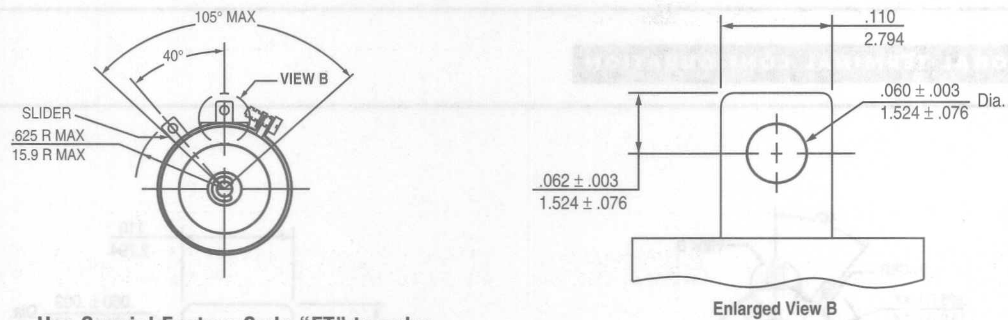
Use Special Feature Code "FT" to order.

Enlarged View B

MODEL 7383 (SERVO MOUNT WITH BALL BEARING)



OPTIONAL TERMINAL CONFIGURATION



Use Special Feature Code "FT" to order.

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft (Standard on single cup 7386 without RS)	SS
Shaft Lock (7381, 7386 only)	SL
High Torque, 2–6 oz.-in. (7386 only)	HT
Additional Gangs	2G
Gold Plated Solder Lug Terminals (See Optional Terminal Configuration)	FT

2

ORDERING INFORMATION

7386 R 10K T2 L .50 XX

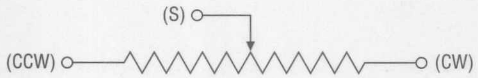
- 7386 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T2 — Optional Non-Standard Tolerance
- L .50 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

7381: RBJ, 2601, 2641

7386: RB, 2126, 2157, 2167, 2606, 2606S, 2607, 2607S, 2626, 2627, 2646, 2646S, 2647, 2647S

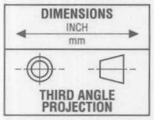
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

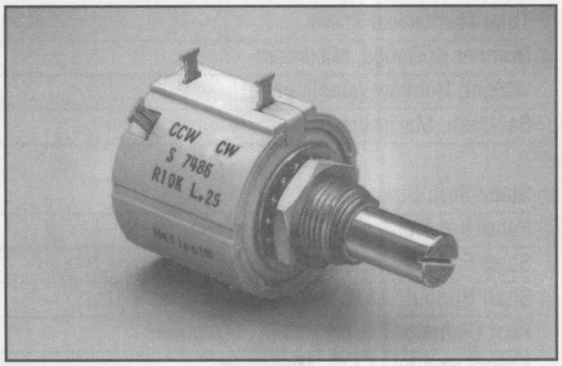
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL SERIES 7480

Distributor Item

7/8" Diameter
5-Turn
Wirewound
Precision Potentiometer



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MODEL STYLES

7481	1/8" Shaft, 1/4" Bushing
7483	1/8" Shaft, Servo
7486	1/4" Shaft, 3/8" Bushing

ELECTRICAL

Resistance Range, Ohms	100 to 50K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.25%, ±0.30%
Minimum Practical Independent Linearity	±0.25%, < 500 Ohms ±0.20%, ≥ 500 Ohms
Power Rating, Watts	1.5 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	1080° + 10° – 0°, > 100 Ohms 1080° + 10° – 5°, ≤ 100 Ohms
Tap Tolerance	±3°
End Voltage, Maximum	0.25% of input voltage

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	Static: –55°C to +125°C Dynamic: –40°C to +125°C
Thermal Shock	5 cycles, –55°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	500K shaft rev. + 900 hrs. at rated wattage at 70°C (5% ΔR)

Specifications subject to change without notice.

MECHANICAL

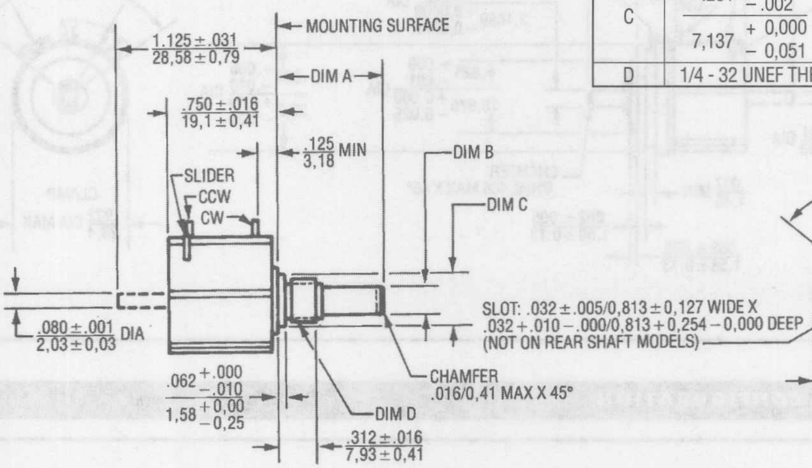
Total Mechanical Travel		1800° + 15° – 0°
Number of Gangs, Maximum		2
Weight, Nominal (single gang)		0.75 oz.
Backlash, Maximum		1°
	7481, 7486	**7483**
Static Stop Strength	60 oz.-in.	36 oz.-in.
Panel Nut Tightening Torque, Maximum	25 lb.-in.	N/A
Shaft End Play, Maximum	.010"	.005"
Shaft Runout, T.I.R., Maximum	.003"	.002"
Pilot Diameter Runout, T.I.R., Maximum	.004"	.002"
Lateral Runout, T.I.R., Maximum	.005"	.004"
Shaft Radial Play, Maximum	.003"	.002"
Start/Run Torque, Maximum (per gang)	1.2 oz.-in.	0.9 oz.-in.

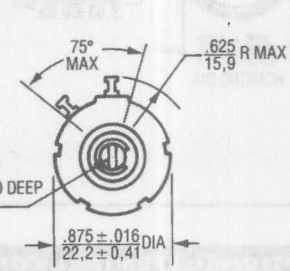
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
100	0.059	±20 ppm/°C
200	0.037	±20 ppm/°C
500	0.030	±20 ppm/°C
1K	0.024	±20 ppm/°C
2K	0.020	±20 ppm/°C
5K	0.018	±20 ppm/°C
10K	0.017	±20 ppm/°C
20K	0.016	±20 ppm/°C

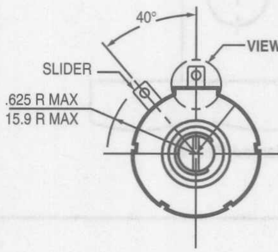
MODEL 7481 & 7468 (BUSHING MOUNT WITH SLEEVE BEARING)

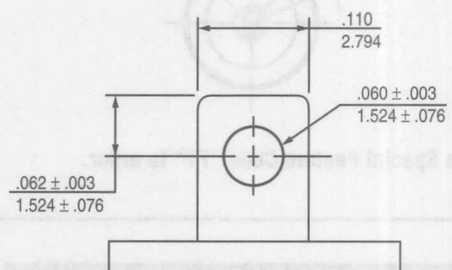
DIM	7481	7486
A	.688 ± .031 / 17,475 ± 0,787	.812 ± .031 / 20,625 ± 0,787
B	.1248 +.0000 −.0003 / 3,1699 + 0,0000 − 0,0076 DIA.	.2500 +.0000 −.0005 / 6,3500 + 0,0000 − 0,0127 DIA.
C	.281 +.000 −.002 / 7,137 + 0,000 − 0,051 DIA.	.406 +.000 −.002 / 10,312 + 0,000 − 0,051 DIA.
D	1/4 - 32 UNEF THREAD	3/8 - 32 UNEF THREAD





OPTIONAL TERMINAL CONFIGURATION

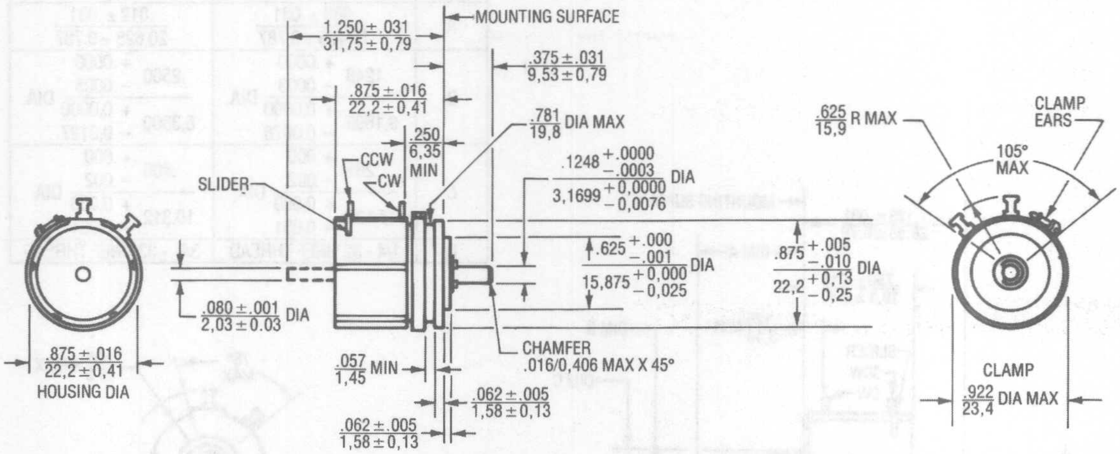




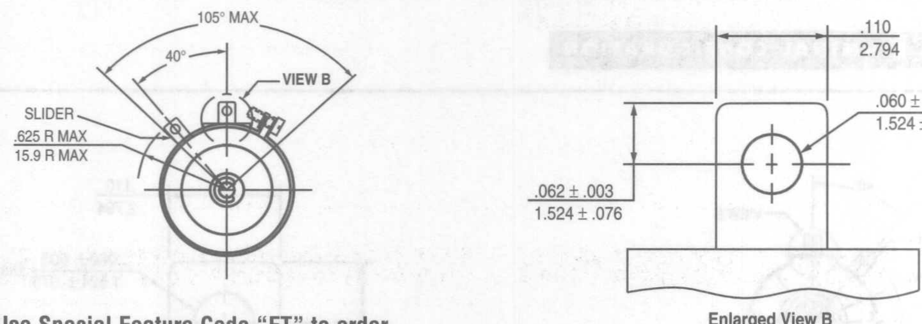
Enlarged View B

Use Special Feature Code "FT" to order.

MODEL 7483 (SERVO MOUNT WITH BALL BEARING)



OPTIONAL TERMINAL CONFIGURATION



Use Special Feature Code "FT" to order.

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft (Standard on single gang 7486 without RS)	SS
Shaft Lock (7481, 7486 only)	SL
High Torque 2–6 oz.-in. (7486 only)	HT
Additional Gangs	2G
Gold plated solder lug terminals (See Optional Terminal Configuration)	FT

ORDERING INFORMATION

7486 R 10K T2 L .30 XX

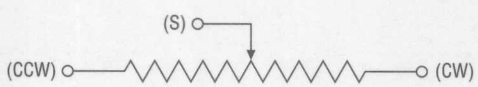
- 7486 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T2 — Optional Non-Standard Tolerance
- L .30 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

7481: RBJ, 2601, 2641

7486: 2606, 2607, 2626, 2627, 2646, 2647, 2157, 2126, 2167, 2606S, 2607S, 2646S, 2647S, RB

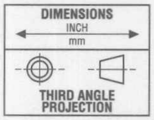
CIRCUIT DIAGRAM



NOTES

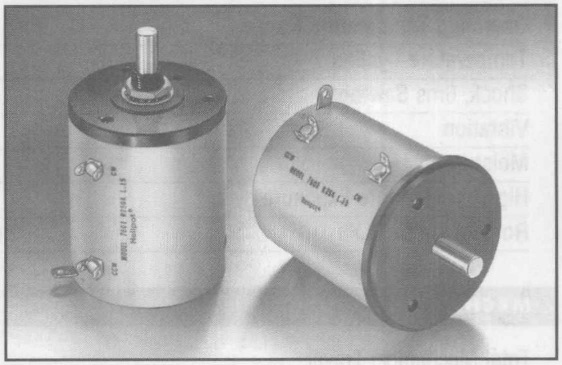
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL SERIES 7600

1-13/16" Diameter
10-Turn
Wirewound
Precision Potentiometer



2

MODEL STYLES

7601	1/4" Shaft, 3/8" Bushing
7603	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	1K to 650K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.15%
Minimum Practical Independent Linearity	±0.1%, < 500 Ohms
	±0.05%, 500-4,999 Ohms
	*±0.025%, ≥ 5K Ohms
Power Rating, Watts	5.0 at 70°C derating to 0 at 125°C
Input Voltage, Maximum	1,000V DC Not to Exceed Power Rating
Dielectric Strength	1,000V RMS
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	3,600° + 3° -0°, ≤ 300 Ohms
	3,600° + 2° -0°, 301-2,500 Ohms
	3,600° + 1° -0°, > 2,500 Ohms
Electrical Continuity Over Travel	+90° ±5° at each end
Tap Tolerance	±2°, ≤ 300 Ohms
	±1°, 301-2,500 Ohms
	±0.5°, ≥ 2,500 Ohms
End Voltage, Maximum	Within Std. Linearity Tolerance

Specifications subject to change without notice.
*May require external pads.

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	–65°C to +125°C
Temperature Cycling	5 cycles, –65°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	5G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	2 mil. shaft rev. plus 900 hrs. at rated wattage at 70°C (5% ΔR)

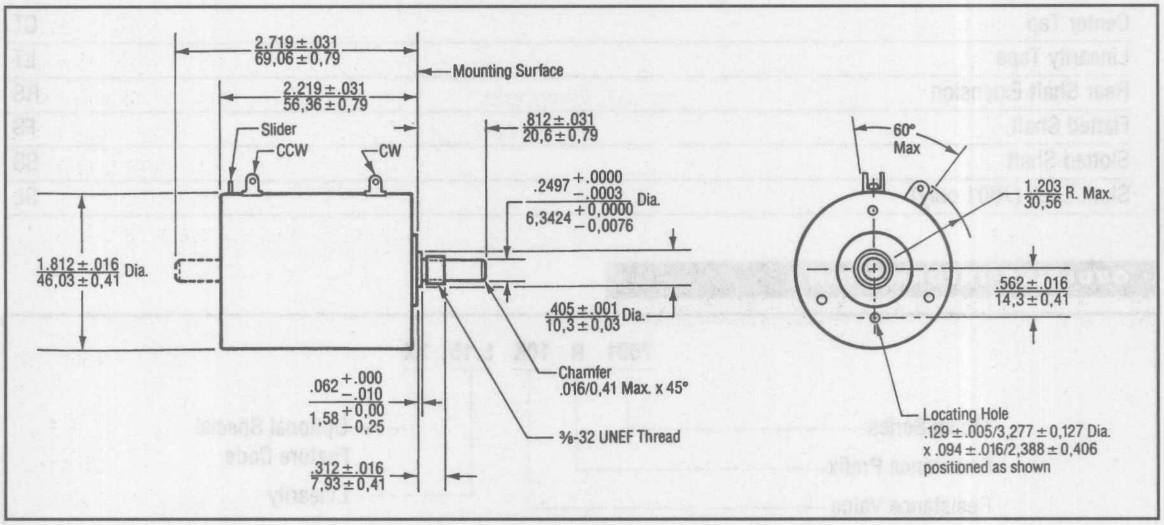
MECHANICAL

Total Mechanical Travel		3,780° ± 5°
Number of Cups, Maximum		2
Weight, Nominal (per gang)		5.5 oz.
Static Stop Strength		600 oz.-in.
Backlash, Maximum		Essentially zero
Shaft End Play, Maximum		.005"
Shaft Runout, T.I.R., Maximum		.0005"
Pilot Diameter Runout, T.I.R., Maximum		.001"
Lateral Runout, T.I.R., Maximum		.0015"
Starting Torque, Maximum		1.3 oz.-in.
Running Torque, Maximum		0.9 oz.-in.
	7601	**7603**
Panel Nut Tightening Torque, Maximum	25 lb.-in.	N/A
Shaft Radial Play, Maximum	0.002"	0.001"

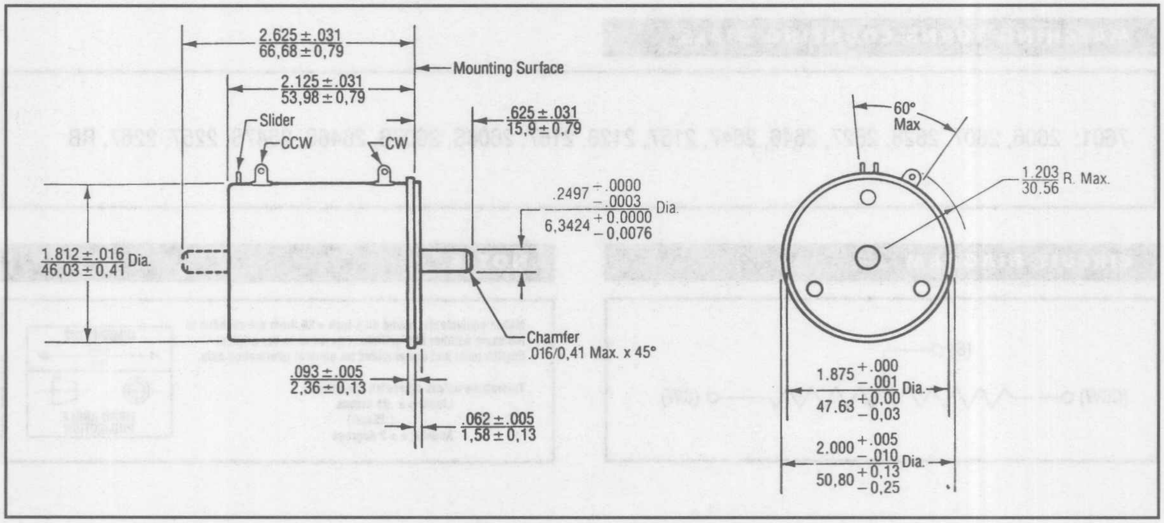
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
1K	0.019	±20 ppm/°C
5K	0.011	±20 ppm/°C
10K	0.012	±20 ppm/°C
20K	0.009	±20 ppm/°C
50K	0.007	±20 ppm/°C
100K	0.006	±20 ppm/°C

MODEL 7601



MODEL 7603



METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock (7601 only)	SL

ORDERING INFORMATION

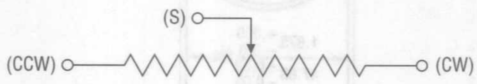
7601 R 10K L.15 XX

- 7601 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- L.15 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

7601: 2606, 2607, 2626, 2627, 2646, 2647, 2157, 2126, 2167, 2606S, 2607S, 2646S, 2647S, 2257, 2267, RB

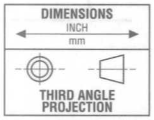
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

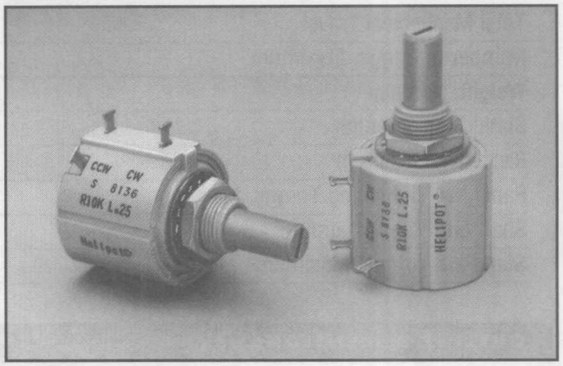
Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL 8136

7/8" Diameter
Plastic 10-Turn
Hybrid
Precision Potentiometer / Position Sensor

Distributor Item



2

FEATURES

Plastic Shaft & Bushing

ELECTRICAL

Resistance Range, Ohms	1K to 100K
Standard Resistance Tolerance	±10%
Independent Linearity	±0.25%
Power Rating, Watts	2.0 at 25°C derating to 0 at 105°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	100 Ohms
Actual Electrical Travel, Nominal	3600°
Tap Tolerance (Voltage Tap Only)	±0.05% of input voltage
End Voltage, Maximum	0.2% of input voltage
Resolution	Essentially Infinite
Temperature Coefficient	+100ppm/°C, -150ppm/°C

ENVIRONMENTAL (MIL-R-12934)

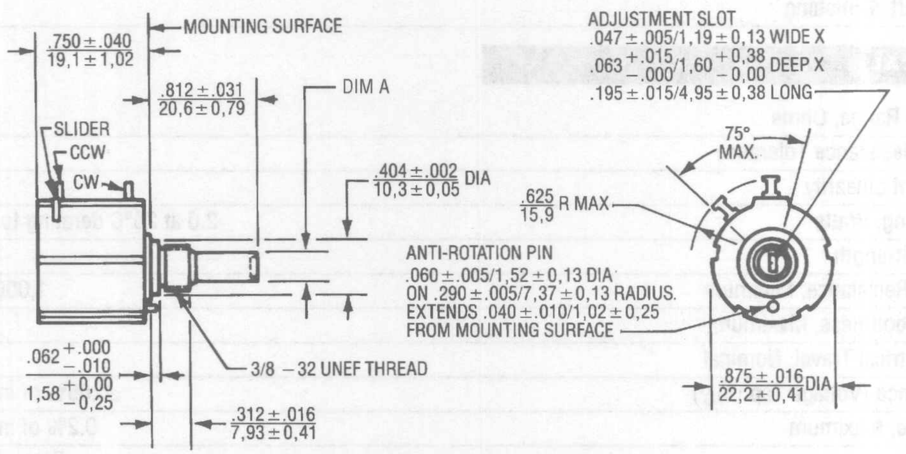
Operating Temperature Range	–25°C to +105°C
Temperature Cycling	5 cycles, –25°C to +105°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	10G's, 10 to 500 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 105°C (5% ΔR)
Rotational Load Life	1 mil. shaft rev. + 900 hrs. at rated wattage at 25°C (5% ΔR)

Specifications subject to change without notice.

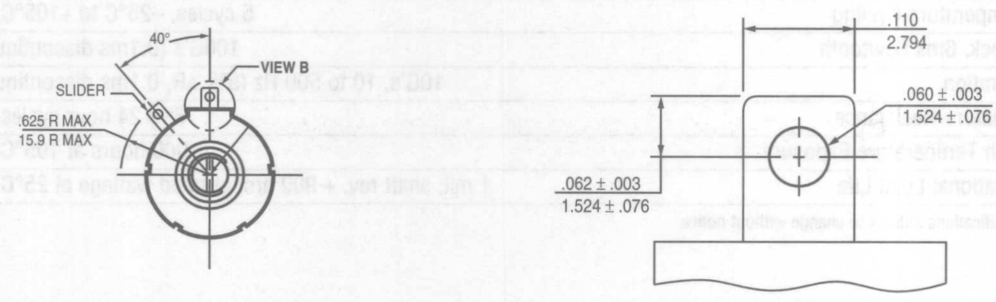
MECHANICAL

Total Mechanical Travel	3600° + 15° – 0°
Number of Gangs, Maximum	1
Weight, Nominal	0.42 oz.
Static Stop Strength	60 oz.-in.
Backlash, Maximum	2°
Panel Nut Tightening Torque, Maximum	8 lb.-in.
Shaft End Play, Maximum	.010"
Start/Run Torque, Maximum	1.5 oz.-in.

OUTLINE DIMENSIONS



OPTIONAL TERMINAL CONFIGURATION



Enlarged View B

Use Special Feature Code "FT" to order.

STANDARD RESISTANCE VALUES, OHMS

1K	2K	5K	10K	20K	50K	100K

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Flatted Shaft	FS
Shaft Lock	SL
Gold Plated Solder Lug Terminals (see Optional Terminal Configuration)	FT

ORDERING INFORMATION

8136 R 10K L.25

- 8136 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- L.25 — Linearity

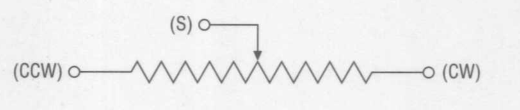
MATCHING TURNS COUNTING DIALS

2606, 2606S, 2607, 2607S, 2626, 2627, 2646, 2646S, 2647, 2647S, 2126, 2157, 2167, RB

METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

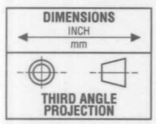
CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches
(.25mm)
Angular = ± 2 degrees



MODEL SERIES 8140

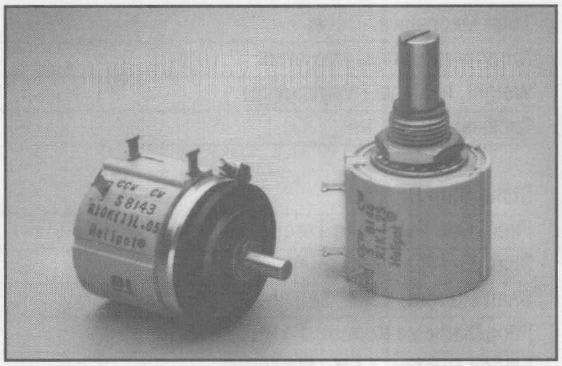
7/8" Diameter

10–Turn Hybrid

Precision Potentiometer /

Position Sensor

Distributor Item



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MODEL STYLES

8141	1/8" Shaft, 1/4" Bushing
8143	1/8" Shaft, Servo
8146	1/4" Shaft, 3/8" Bushing

ELECTRICAL

Resistance Range, Ohms	1K to 100K
Standard Resistance Tolerance	±10%
Minimum Practical Resistance Tolerance	±5%
Independent Linearity	±0.25%
Power Rating, Watts	2.0 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Output Smoothness, Maximum	0.05%≤5K Ohms, 0.03%>5K Ohms
Actual Electrical Travel, Nominal	3600°
Tap Tolerance (Voltage Tap Only)	±0.05% of input voltage
End Voltage, Maximum	0.2% of input voltage
Resolution	Essentially Infinite
Temperature Coefficient	+100ppm/°C, -150ppm/°C

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	–55°C to +125°C
Temperature Cycling	5 cycles, –40°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	100G's (0.1ms discontinuity max.)
Vibration	15G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Five 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	5 mil. shaft rev. + 900 hrs. at rated wattage at 70°C (5% ΔR)

Specifications subject to change without notice.

MECHANICAL

Total Mechanical Travel		3600° + 15° – 0°
Number of Gangs, Maximum		2
Weight, Nominal (single gang)		0.75 oz.
Backlash, Maximum		1°
	8141, 8146	**8143**
Static Stop Strength	60 oz.-in.	36 oz.-in.
Panel Nut Tightening Torque, Maximum	25 lb.-in.	NA
Shaft End Play, Maximum	.010"	.005"
Shaft Runout, T.I.R., Maximum	.003"	.002"
Pilot Diameter Runout, T.I.R., Maximum	.004"	.002"
Lateral Runout, T.I.R., Maximum	.005"	.004"
Shaft Radial Play, Maximum	.003"	.002"
Start/Run Torque, Maximum (per gang)	0.8 oz.-in.	0.6 oz.-in.

STANDARD RESISTANCE VALUES, OHMS

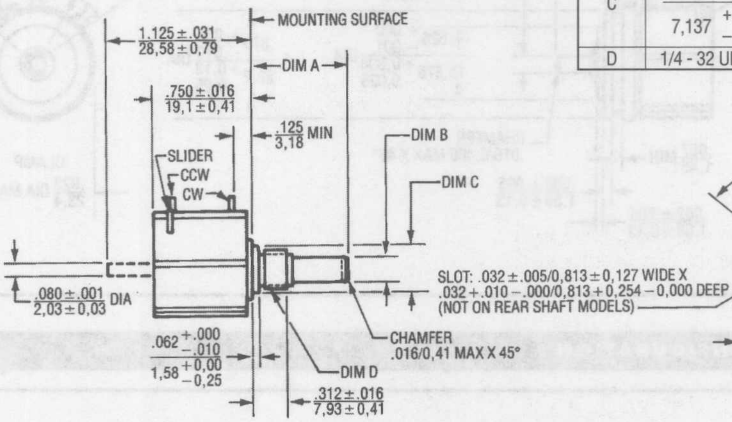
1K	2K	5K	10K	20K	50K	100K

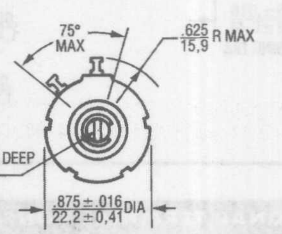
METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

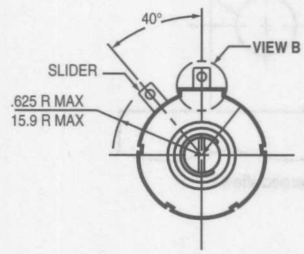
MODEL 8141 & 8146 (BUSHING MOUNT WITH SLEEVE BEARING)

DIM	8141	8146
A	.688 ± .031 / 17,475 ± 0,787	.812 ± .031 / 20,625 ± 0,787
B	.1248 +.0000 −.0003 / 3,1699 + 0,0000 − 0,0076 DIA.	.2500 +.0000 −.0005 / 6,3500 + 0,0000 − 0,0127 DIA.
C	.281 +.000 −.002 / 7,137 + 0,000 − 0,051 DIA.	.406 +.000 −.002 / 10,312 + 0,000 − 0,051 DIA.
D	1/4 - 32 UNEF THREAD	3/8 - 32 UNEF THREAD

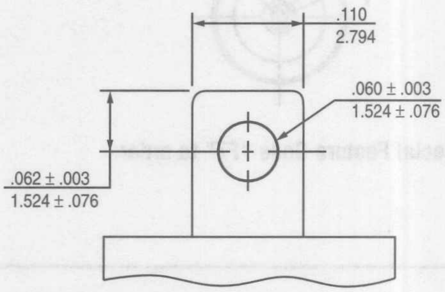




OPTIONAL TERMINAL CONFIGURATION

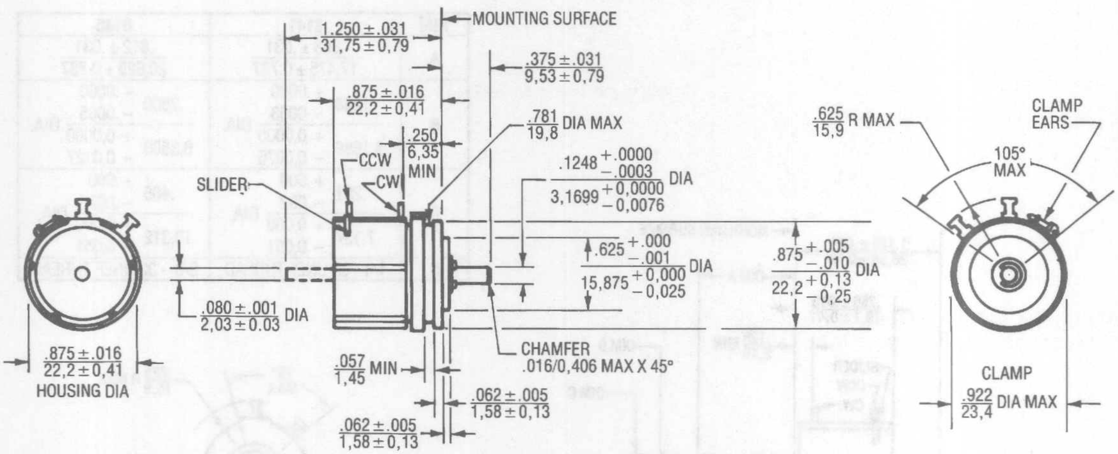


Use Special Feature Code "FT" to order.

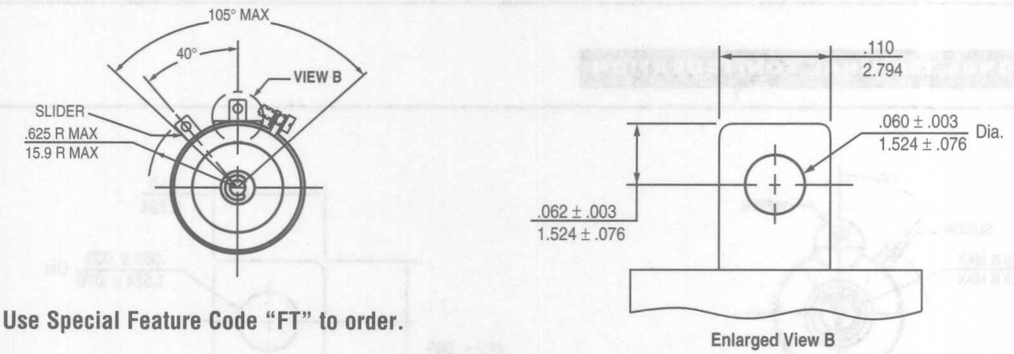


Enlarged View B

MODEL 8143 (SERVO MOUNT WITH BALL BEARING)



OPTIONAL TERMINAL CONFIGURATION



Use Special Feature Code “FT” to order.

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension (8143, 8146 single cup only)	RS
Flatted Shaft	FS
Slotted Shaft (Standard on single gang 8146 without RS)	SS
Shaft Lock (8141, 8146 only)	SL
High Torque 2–6 oz.-in. (8146 only)	HT
Additional Gangs	2G
Gold plated solder lug terminals (See Optional Terminal Configuration)	FT

2

ORDERING INFORMATION

8146 R 10K T5 L .25 XX

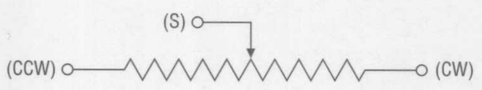
- 8146 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- T5 — Optional Non-Standard Tolerance
- L .25 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

8141: RBJ, 2601, 2641

8146: 2606, 2607, 2626, 2627, 2646, 2647, 2157, 2126, 2167, 2606S, 2607S, 2646S, 2647S, RB

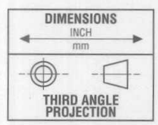
CIRCUIT DIAGRAM



NOTES

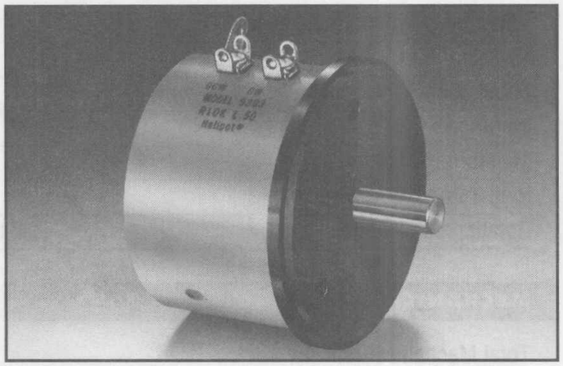
Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees



MODEL SERIES 9300

1-13/16" Diameter
3-Turn
Wirewound
Precision Potentiometer



2

MODEL STYLES

9301	1/4" Shaft, 3/8" Bushing
9303	1/4" Shaft, Servo

ELECTRICAL

Resistance Range, Ohms	30 to 190K
Standard Resistance Tolerance	±5%
Minimum Practical Resistance Tolerance	±1%
Independent Linearity	±0.25%
Minimum Practical Independent Linearity	±0.2%, < 150 Ohms ±0.1%, 150-1,500 Ohms ±0.05%, 1,501-9,999 Ohms ±0.04%, ≥10K Ohms
Power Rating, Watts	3.0 at 70°C derating to 0 at 125°C
Dielectric Strength	1,000V rms
Insulation Resistance, Minimum	1,000 Megohms
Noise, Maximum	100 Ohms
Actual Electrical Travel	1,080° + 3° – 0°, ≤100 Ohms 1,080° + 2° – 0°, 101-700 Ohms 1,080° + 1° – 0°, >700 Ohms
Electrical Continuity Over Travel	+90° ±5° at each end
Tap Tolerance	±2°, ≤100 Ohms ±1°, 101-700 Ohms ±0.5°, >700 Ohms
End Voltage, Maximum	Within Std. Linearity Tolerance

Specifications subject to change without notice.

ENVIRONMENTAL (MIL-R-12934)

Operating Temperature Range	−65°C to +125°C
Temperature Cycling	5 cycles, −65°C to +125°C (5% ΔR)
Shock, 6ms Sawtooth	50G's (0.1ms discontinuity max.)
Vibration	5G's, 10 to 2,000 Hz (5% ΔR, 0.1ms discontinuity max.)
Moisture Resistance	Ten 24 hour cycles (3% ΔR)
High Temperature Exposure	1,000 hours at 125°C (5% ΔR)
Rotational Load Life	2 mil. shaft rev. plus 900 hrs. at rated wattage at 70°C (5% ΔR)

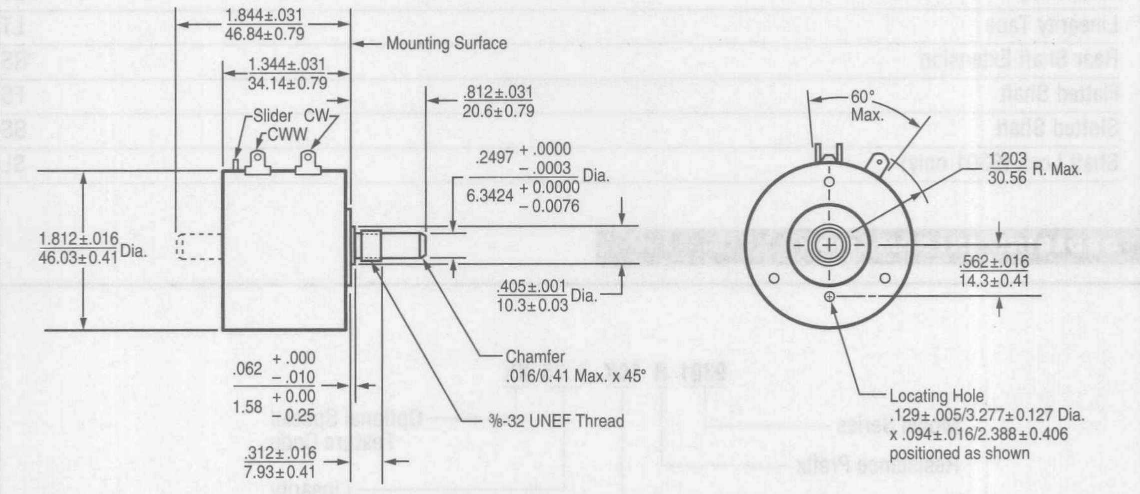
MECHANICAL

Total Mechanical Travel		1260° ± 5°
Number of Cups, Maximum		3
Weight, Nominal (per gang)		3.4 oz.
Static Stop Strength		600 oz.-in.
Backlash, Maximum		Essentially zero
Shaft End Play, Maximum		.005"
Shaft Runout, T.I.R., Maximum		.0005"
Pilot Diameter Runout, T.I.R., Maximum		.001"
Lateral Runout, T.I.R., Maximum		.0015"
Starting Torque, Maximum		1.3 oz.-in.
Running Torque, Maximum		0.9 oz.-in.
	9301	**9303**
Panel Nut Tightening Torque, Maximum	25 lb.-in.	N/A
Shaft Radial Play, Maximum	0.002"	0.001"

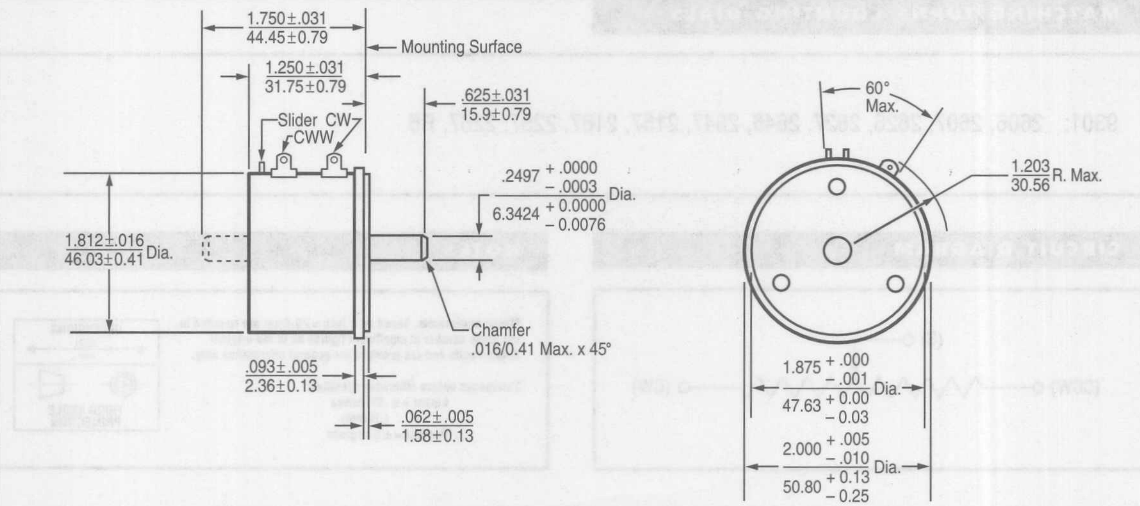
STANDARD RESISTANCE VALUES, OHMS

Total Resistance	Theoretical Resolution (% Nominal)	Tempco of Wire
1K	0.039	±20 ppm/°C
5K	0.032	±20 ppm/°C
10K	0.027	±20 ppm/°C
20K	0.021	±20 ppm/°C
50K	0.017	±20 ppm/°C

MODEL 9301



MODEL 9303



METRIC CONVERSIONS

1 in.	25,4mm	1 oz.-in.	0,007 N-m
1 oz.	28.4 gm	1 lb.-in.	0,113 N-m

SPECIAL FEATURE CODES

Center Tap	CT
Linearity Tape	LT
Rear Shaft Extension	RS
Flatted Shaft	FS
Slotted Shaft	SS
Shaft Lock (9301 only)	SL

ORDERING INFORMATION

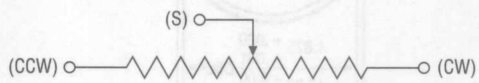
9301 R 10K L.25 XX

- 9301 — Model Series
- R — Resistance Prefix
- 10K — Resistance Value
- L.25 — Linearity
- XX — Optional Special Feature Code

MATCHING TURNS COUNTING DIALS

9301: 2606, 2607, 2626, 2627, 2646, 2647, 2157, 2167, 2257, 2267, RB

CIRCUIT DIAGRAM



NOTES

Metric equivalents, based on 1 inch = 25.4mm are rounded to the same number of significant figures as in the original English units and are provided for general information only.

Tolerances unless otherwise specified:
Linear = ± .01 inches (.25mm)
Angular = ± 2 degrees

DIMENSIONS
INCH
mm

THIRD ANGLE PROJECTION

Application Notes

Precision Potentiometers

2

PRECISION POTENTIOMETERS/ POSITION SENSORS

1 TERMS AND DEFINITIONS

The terms and definitions used in this section have been edited from the Variable Resistive Components Institute (VRCI) data for precision potentiometers. VRCI publishes generally accepted terms, definitions and test standards for precision potentiometers and for other variable resistive devices. If you would like additional information or definition on industry standards, please contact one of our application engineers.

1.1 LIST OF SYMBOLS

C	Conformity
CT	Center Tap
CW	Clockwise
CCW	Counterclockwise
E	Total Applied Voltage
e	Output Voltage
e_i	Inphase Output Voltage
e_q	Quadrature Voltage
e/E	Output Ratio (Output Voltage Ratio)
V_e	End Voltage
R_T	Total Resistance
R_L	Load Resistance
R_e	End Resistance
TC	Temperature Coefficient of Resistance
RTC	Resistance-Temperature Characteristic
A	Output Slope
G	Gradient
θ	Shaft Position
ϕ	Phase Shift
θ_T	Theoretical Electrical Travel
θ_A	Actual Electrical Travel

1.2 GENERAL TERMS

1.2.1 PRECISION POTENTIOMETER:

A mechanical-electrical transducer dependent upon the relative position of a moving contact (wiper) and a resistance element for its operation. It delivers to a high degree of accuracy a voltage output that is some specified function of applied voltage and shaft position.

1.2.1.1 WIREWOUND PRECISION POTENTIOMETER:

A precision potentiometer characterized by a resistance element made up of turns of wire on which the wiper contacts only a small portion of each turn.

1.2.1.2 NONWIREWOUND PRECISION POTENTIOMETER:

A precision potentiometer characterized by the continuous nature of the resistance element in the direction of wiper travel.

1.2.3 CUP:

A single mechanical section of a potentiometer which may contain one or more electrical resistance elements.

1.2.4 GANG:

An assembly of two or more cups on a common operating shaft.

1.2.5 SHAFT:

The mechanical input element of the potentiometer.

1.2.6 SHAFT POSITION:

An indication of the position of the wiper relative to a reference point.

1.2.7 TERMINAL:

An external member that provides electrical access to the potentiometer resistance element and wiper.

1.2.8 INTEGRAL RESISTOR:

An internal or external resistor preconnected to the electrical element and forming an integral part of the cup assembly to provide a desired electrical characteristic. The resistor may be a separate entity, a part of the wirewound or nonwirewound resistance element or a layer type resistor formed on the same insulating substrate as the resistance element.

1.2.9 TEST POINT:
An additional terminal used only to facilitate measurements.

1.2.10 TAP

1.2.10.1 CURRENT TAP:
An electrical connection fixed to the resistance element which is capable of carrying rated element current and may distort the output characteristic.
Note: Current taps on non-wirewound units commonly have significant width, but low resistance. See paragraph 3.13.

1.2.10.2 VOLTAGE TAP:
An electrical connection fixed to the resistance element which introduces no significant distortion in the output characteristic. A voltage tap usually has significant tap resistance and may not be capable of carrying rated element current.
Note: The distinction between current and voltage taps basically applies to taps on non-wirewound units. Most taps on wirewound potentiometers are attached to one turn of wire and can carry rated element current. They do not usually have an effect on resolution or output characteristics.

2 INPUT AND OUTPUT TERMS

2.1 INPUT TERMS

2.1.1 TOTAL APPLIED VOLTAGE: (E)
The total voltage applied between the designated input terminals.
Note: When plus (+) and minus (-) voltages are applied to the potentiometer, the Total Applied Voltage (commonly called peak-to-peak applied voltage) is equal to the sum of the two voltages. Each individual voltage is referred to as zero-to-peak applied voltage.

2.2 OUTPUT TERMS

2.2.1 OUTPUT VOLTAGE:
The voltage between the wiper and the designated reference point. Unless otherwise specified, the designated reference point is the CCW terminal.

2

2.2.2 OUTPUT RATIO:
The ratio of the Output Voltage to the designated input reference voltage. Unless otherwise specified, the reference voltage is the Total Applied Voltage (see Figure 2.1.1).

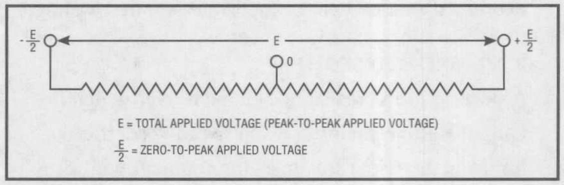


FIGURE 2.1.1 Total Applied Voltage

2.2.3 TOTAL VARIABLE OUTPUT:
The difference between the maximum and minimum Output Ratios. These ratios correspond to the Minimum Voltages at each input terminal.

2.2.4 END VOLTAGE:

2.2.4.1 END VOLTAGE–WIREWOUND:
The voltage between the wiper terminal and an end terminal when the shaft is positioned at the corresponding End Point. End Voltage is expressed as a percent of the Total Applied Voltage.

2.2.4.2 END VOLTAGE–NONWIREWOUND:
The voltage between the wiper terminal and an end terminal when the shaft is positioned at the corresponding Theoretical End Point. End Voltage is expressed as a percent of the Total Applied Voltage.

2.2.5 MINIMUM VOLTAGE:

The smallest or lowest voltage between the wiper terminal and an end terminal when the shaft is positioned near the corresponding end of Electrical Continuity Travel. Minimum Voltage is expressed as a percent of the Total Applied Voltage.

2.2.6 JUMP-OFF VOLTAGE (WIREWOUND POTENTIOMETERS ONLY):

The magnitude of the first measurable voltage change as the wiper moves from the overtravel region onto the Actual Electrical Travel. It is expressed as a percent of the Total Applied Voltage.

2.2.7 SHORTED SEGMENT:

A portion of the resistance element over which the Output Ratio remains constant within specified limits as the wiper traverses the segment with a specified Load Resistance.

2.2.8 OUTPUT SLOPE:

The ratio between the rate of change of Output Ratio and the rate of change of shaft travel.
θ_A may be substituted for θ_T where applicable.

MATHEMATICALLY: $$A = \frac{\triangle \frac{e}{E}}{\triangle \frac{\theta}{\theta_T}}$$

Note: The theoretical output slope is the first derivative of the normalized Theoretical Function Characteristic.

MATHEMATICALLY: $$A = \frac{df(\theta / \theta_T)}{d(\theta / \theta_T)} = \frac{d(e / E)}{d(\theta / \theta_T)}$$

2.2.9 SLOPE RATIO:

The ratio of the largest to the smallest Output Slopes of a monotonic Theoretical Function Characteristic.

2.2.10 GRADIENT:

The rate of change of Output Ratio relative to shaft travel.

MATHEMATICALLY: $$G = \frac{d(e / E)}{d\theta}$$

2.3 LOAD TERMS

2.3.1 LOAD RESISTANCE: (R_L)

The external resistance as seen by the Output Voltage (connected between the wiper and the designated reference point).

Note: No load means an infinite Load Resistance.

2.3.2 LOADING ERROR:

The difference between the Output Ratio with an infinite Load Resistance and the Output Ratio with a specified finite Load Resistance, at the same shaft position.

Note: Elimination of Loading Error, by compensating the resistance element to give the desired output with a specified Load Resistance, is referred to as "Load Compensation."

3 ROTATION AND TRANSLATION

3.1 DIRECTION OF TRAVEL:

For rotary potentiometers, clockwise (CW) or counterclockwise (CCW) when viewing the specified mounting end of the potentiometer. The designation of terminals in the figure corresponds to the direction of shaft travel.

For translatory potentiometers, "extending" or "retracting" when viewing the specified end of the potentiometer.

The Output Ratio and shaft position increases with clockwise (or extending) direction of travel unless otherwise specified.

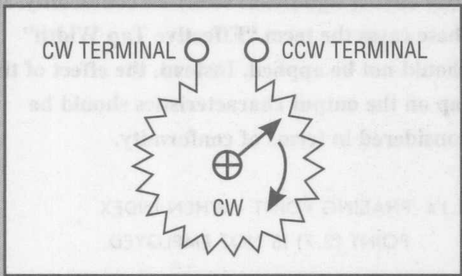


FIGURE 3.1 View of shaft and element from specified mounting end.

3.2 TOTAL MECHANICAL TRAVEL:

The total travel of the shaft between integral stops, under specified stop load. In potentiometers without stops, the mechanical travel is continuous.

3.3 MECHANICAL OVERTRAVEL

3.3.1 MECHANICAL OVERTRAVEL–WIREWOUND:

The shaft travel between each End Point (or Theoretical End Point for Absolute Conformity or Linearity units) and its adjacent corresponding limit of Total Mechanical Travel.

3.3.2 MECHANICAL OVERTRAVEL - NONWIREWOUND:

The shaft travel between each Theoretical End Point and its adjacent corresponding limit of Total Mechanical Travel.

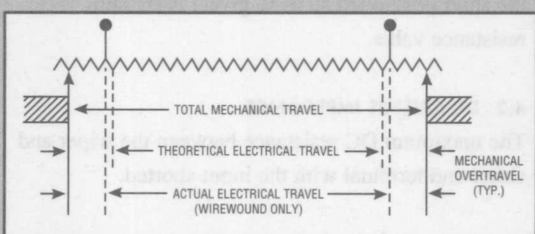


FIGURE 3.3.2 Mechanical overtravel

Note: The relationship of the electrical travels to each other and to the input terminals shown above is given for illustration only and may vary from one potentiometer to another.

3.4 BACKLASH:

The maximum difference in shaft position that occurs when the shaft is moved to the same actual Output Ratio point from opposite directions.

3.5 END POINT (WIREWOUND POTENTIOMETERS ONLY):

The shaft positions immediately before the first and after the last measurable change(s) in Output Ratio, after wiper continuity has been established, as the shaft moves in a specified direction.

3.6 THEORETICAL END POINT:

The shaft positions corresponding to the ends of the Theoretical Electrical Travel as determined from the Index Point.

3.7 INDEX POINT:

A point of reference fixing the relationship between a specified shaft position and the Output Ratio. It is used to establish a shaft position reference.

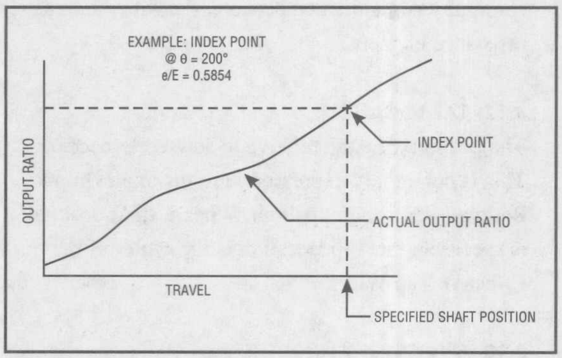


FIGURE 3.7 Index point

3.8 ACTUAL ELECTRICAL TRAVEL (WIREWOUND POTENTIOMETERS ONLY):

The total travel of the shaft between End Points.

3.9 THEORETICAL ELECTRICAL TRAVEL:
The specified shaft travel over which the theoretical function characteristic extends between defined Output Ratio limits, as determined from the Index Point.

3.10 ELECTRICAL OVERTRAVEL

3.10.1 ELECTRICAL OVERTRAVEL - WIREWOUND:
The shaft travel over which there is continuity between the wiper terminal and the resistance element beyond each end of the Actual Electrical Travel. (Theoretical Electrical Travel is substituted for Actual Electrical Travel in Absolute Conformity or Linearity units.)

3.10.2 ELECTRICAL OVERTRAVEL - NONWIREWOUND:
The shaft travel over which there is continuity between the wiper terminal and the resistance element beyond each end of the Theoretical Electrical Travel.

3.11 ELECTRICAL CONTINUITY TRAVEL:
The total travel of the shaft over which electrical continuity is maintained between the wiper and the resistance element.

3.12 TAP LOCATION:
The position of a tap relative to some reference. This is commonly expressed in terms of an Output Ratio and/or a shaft position. When a shaft position is specified, the Tap Location is the center of the Effective Tap Width.

3.13 EFFECTIVE TAP WIDTH:
The travel of the shaft during which the voltage at the wiper terminal and the tap terminal are the same, as the wiper is moved past the tap in one direction.

Note: In some instances, particularly nonwirewound pots, the tap width may be essentially zero (i.e., no flat zone), but the tap may have a significant effect on conformity. In these cases the term "Effective Tap Width" should not be applied. Instead, the effect of the tap on the output characteristics should be considered in terms of conformity.

3.14 PHASING POINT - WHEN INDEX POINT (3.7) IS NOT EMPLOYED

3.14.1 PHASING POINT – WIREWOUND:
A reference point on a cup of a gang, usually an Output Ratio, an End Point or an intermediate tap.

3.14.2 PHASING POINT– NONWIREWOUND:
A reference point on a cup of a gang, usually an Output Ratio or an intermediate tap (not an end tap).

3.15 PHASING (SEE ALSO SIMULTANEOUS CONFORMITY PHASING PARA.5.10):
The relative alignment of the Phasing Points of each cup of a gang potentiometer.
Note: Unless otherwise specified, phasing requirements apply to a single specified Phasing Point in each cup and all cups are aligned to the Phasing Point of the first cup.

4 RESISTANCE

4.1 TOTAL RESISTANCE (DC INPUT IMPEDANCE):
The DC resistance between the input terminals with the shaft positioned so as to give a maximum resistance value.

4.2 DC OUTPUT IMPEDANCE:
The maximum DC resistance between the wiper and either end terminal with the input shorted.

4.3 MINIMUM RESISTANCE

4.3.1 MINIMUM RESISTANCE - WIREWOUND:
The resistance measured between the wiper terminal and any terminal with the shaft positioned to give a minimum value.

4.3.2 MINIMUM RESISTANCE - NONWIREWOUND:
Refer to Tap Resistance (4.5) or Minimum Voltage (2.2.5) for applicable definition.

4.4 END RESISTANCE

4.4.1 END RESISTANCE – WIREWOUND:
The resistance measured between the wiper terminal and an end terminal with the shaft positioned at the corresponding End Point.

4.4.2 END RESISTANCE – NONWIREWOUND:
Refer to End Voltage (2.2.4.2) for applicable definition.

4.5 TAP RESISTANCE (NONWIREWOUND POTENTIOMETERS ONLY):
The minimum resistance obtainable between a tap terminal and a wiper position on the resistance element, measured without drawer wiper current. **Note: This definition applies only to intermediate taps. For End Terminations refer to End Voltage (2.2.4.2).**

4.6 APPARENT CONTACT RESISTANCE (NONWIREWOUND POTENTIOMETERS ONLY):
Refer to Output Smoothness (6.2).

4.7 EQUIVALENT NOISE RESISTANCE (ENR)

4.7.1 EQUIVALENT NOISE RESISTANCE–WIREWOUND:
Refer to Noise (6.1).

4.7.2 EQUIVALENT NOISE RESISTANCE–NONWIREWOUND:
Refer to Output Smoothness (6.2).

4.8 TEMPERATURE COEFFICIENT OF RESISTANCE (WIREWOUND POTENTIOMETERS ONLY):
The unit change in resistance per degree Celsius change from a reference temperature, expressed in parts per million per degree Celsius as follows:

$$\boxed{T.C. = \frac{R_2 - R_1}{R_1(T_2 - T_1)} \times 10^6}$$

Where:
R_1 = Resistance at reference temperature in ohms.
R_2 = Resistance at test temperature in ohms.
T_1 = Reference temperature in degrees Celsius.
T_2 = Test temperature in degrees Celsius.

4.9 RESISTANCE - TEMPERATURE CHARACTERISTIC (NONWIREWOUND POTENTIOMETERS ONLY):
The change in Total Resistance over a specified temperature range expressed as a percent of the Total Resistance at a specified reference temperature.

$$\boxed{RTC = \frac{R_2 - R_1}{R_1} \times 100}$$

Where:
R_1 = Resistance at reference temperature in ohms.
R_2 = Maximum or minimum resistance at any of the test temperatures, in ohms.

2

Note: Although Temperature Coefficient of Resistance can be applied to Nonwirewounds, the Tempco of many Nonwirewounds is not linear over the normal use temperature range and this can be misleading.

5 CONFORMITY AND LINEARITY

5.1 FUNCTION CHARACTERISTIC:

The relationship between the Output Ratio and the shaft position.

MATHEMATICALLY: $\frac{e}{E} = f(\theta)$

5.2 CONFORMITY:

The fidelity of the relationship between the actual function characteristic and the theoretical function characteristic.

MATHEMATICALLY: $\frac{e}{E} = f(\theta)$

5.3 ABSOLUTE CONFORMITY:

The maximum deviation of the actual function characteristic from a fully defined theoretical function characteristic. It is expressed as a percentage of the Total Applied Voltage and measured over the Theoretical Electrical Travel. An Index Point on the actual output is required.

MATHEMATICALLY: $\frac{e}{E} = f(\theta / \theta_T) \pm C;\ 0 \leq \theta \leq \theta_T$

Note: The theoretical function characteristic is assumed to be a smooth curve when it can be described by a mathematical expression. When empirical data are provided, the points are assumed to be joined by straight line segments.

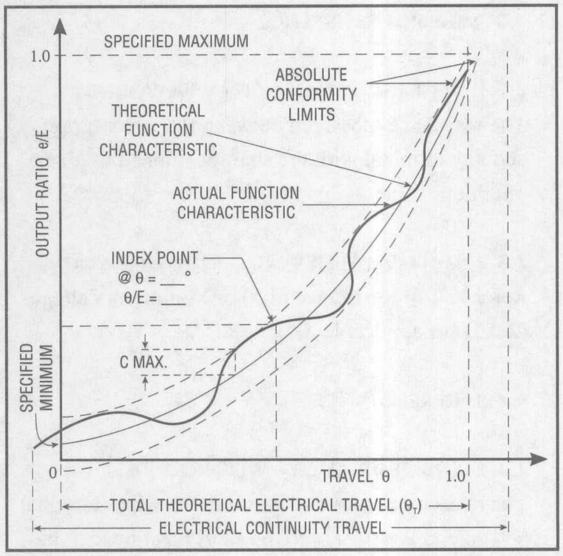


FIGURE 5.3 Absolute Conformity

5.4 LINEARITY:

A specific type of conformity where the theoretical function characteristic is a straight line.

MATHEMATICALLY: $\frac{e}{E} = A(\theta / \theta_T) + B \pm C$

Where:

A is given slope; B is given intercept at $\theta = 0$.

5.5 ABSOLUTE LINEARITY:

The maximum deviation of the actual function characteristic from a fully defined straight reference line. It is expressed as a percentage of the Total Applied Voltage and measured over the Theoretical Electrical Travel. An Index Point on the actual output is required.

The straight reference line may be fully defined by specifying the low and high theoretical end Output Ratios separated by the Theoretical Electrical Travel. Unless otherwise specified, these end Output Ratios are 0.0 and 1.0, respectively.

$$\text{MATHEMATICALLY:} \quad \frac{e}{E} = A(\theta / \theta_T) + B \pm C$$

Where:

A is given slope; B is given intercept at $\theta = 0$.

Unless otherwise specified:

$A = 1; B = 0$.

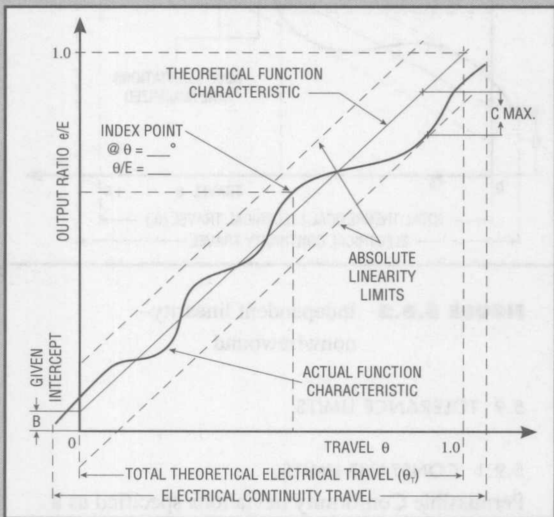


FIGURE 5.5 Absolute linearity

5.6 TERMINAL BASED LINEARITY (WIREWOUND POTENTIOMETERS ONLY):

The maximum deviation, expressed as a percent of the Total Applied Voltage, of the actual function characteristic from a straight reference line drawn through the specified minimum and maximum Output Ratios which are separated by the Actual Electrical Travel. Unless otherwise specified, minimum and maximum Output Ratios are, respectively, zero and 100% of Total Applied Voltage.

$$\text{MATHEMATICALLY:} \quad \frac{e}{E} = A(\theta / \theta_A) + B \pm C$$

Where:

A is given slope; B is given intercept at $\theta = 0$.

Unless otherwise specified:

$A = 1; B = 0$.

5.7 ZERO BASED LINEARITY (WIREWOUND POTENTIOMETERS ONLY):

The maximum deviation, expressed as a percent of Total Applied Voltage, of the actual function characteristic from a straight reference line drawn through the specified minimum Output Ratio, extended over the Actual Electrical Travel, with its slope chosen to minimize the maximum deviations. Any specified End Voltage requirement may limit the slope of the reference line. Unless otherwise specified, the specified minimum Output Ratio will be zero.

$$\text{MATHEMATICALLY:} \quad \frac{e}{E} = P(\theta / \theta_A) + B \pm C$$

Where:

P is unspecified slope limited by the End Voltage requirements, at the maximum output ratio end.

Unless otherwise specified:

$B = 0$.

5.8 INDEPENDENT LINEARITY (BEST STRAIGHT LINE)

5.8.1 INDEPENDENT LINEARITY - WIREWOUND:

The maximum deviation, expressed as a percent of the Total Applied Voltage, of the actual function characteristic from a straight reference line with its slope and position chosen to minimize deviations over the Actual Electrical Travel, or any specified portion thereof.

Note: End Voltage requirements, when specified, will limit the slope and position of the reference line.

$$\text{MATHEMATICALLY:} \quad \frac{e}{E} = P(\theta / \theta_A) + Q \pm C$$

Where:
P is unspecified slope; Q is unspecified intercept at $\theta = 0$. And both are chosen to minimize C but are limited by the End Voltage requirements.

5.8.2 INDEPENDENT LINEARITY - NONWIREWOUND:

The maximum deviation of the actual function characteristics from a straight reference line with its slope and position chosen to minimize the maximum deviations. It is expressed as a percentage of the Total Applied Voltage and is measured over the specified Theoretical Electrical Travel. The slope of the reference line, if limited, must be separately specified. An Index Point on the actual output is required. Unless otherwise specified, the Index Point will be at $\theta = \frac{\theta_T}{2}$.

$$\text{MATHEMATICALLY:} \quad \frac{e}{E} = P(\theta / \theta_T) + Q \pm C$$

Where:
P is unspecified slope; Q is unspecified intercept at $\theta = 0$. And both are chosen to minimize C but are limited by the End Voltage requirements.

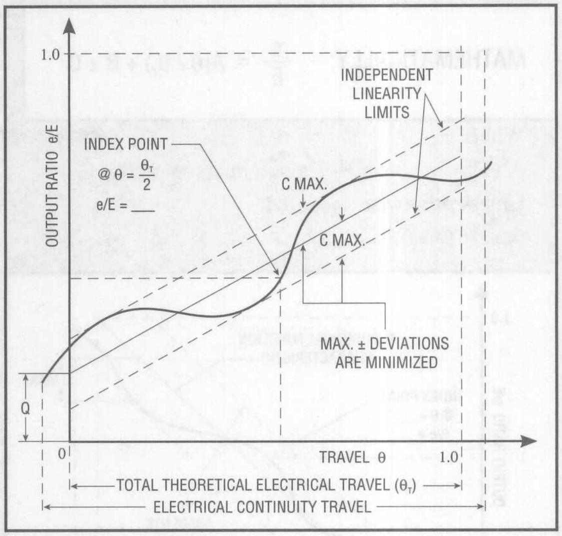


FIGURE 5.8.2 Independent linearity–nonwirewound

5.9 TOLERANCE LIMITS

5.9.1 CONSTANT LIMITS:

Permissible Conformity deviations specified as a percentage of the Total Applied Voltage.
Note: Unless otherwise specified, all definitions in this document employ Constant Limits.

5.9.1.1 ZERO-TO-PEAK CONSTANT LIMITS:

Permissible Conformity deviations specified as a percentage of Zero-To-Peak Applied Voltage.
Note: The numerical value of zero-to-peak errors is double that of equal peak-to-peak errors, because the reference zero-to-peak applied voltage is one-half of the Total (peak-to-peak) Applied Voltage (see 2.1.1).

5.9.2 PROPORTIONAL LIMITS:

Permissible Conformity deviations specified as a percentage of the theoretical Output Ratio at the point of measurement.
Note: Proportional limits may become impossibly restrictive in the vicinity of zero theoretical output and should be modified to provide a practical tolerance in that region, if the theoretical Output Ratio approaches zero.

5.9.3 MODIFIED PROPORTIONAL LIMITS:
Any combination of Constant and Proportional Limits.

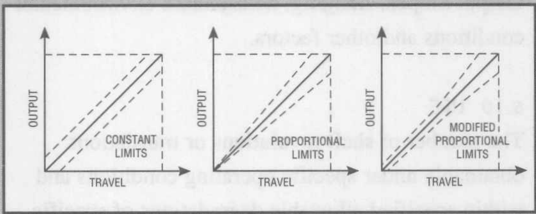


FIGURE 5.9.3 Tolerance limits

5.10 SIMULTANEOUS CONFORMITY PHASING:
The relative alignment of the cups of a gang potentiometer, from a common index point, such that the Output Ratios of all cups fall within their respective Conformity limits over the Theoretical Electrical Travel.

5.11 VOLTAGE TRACKING ERROR:
The difference, at any shaft position, between the Output Ratios of any two commonly actuated similar electrical elements, expressed as a percentage of the single total voltage applied to them.

6 GENERAL ELECTRICAL CHARACTERISTICS

6.1 NOISE (WIREWOUND POTENTIOMETERS ONLY):
Any spurious variation in the electrical output not present in the input, defined quantitatively in terms of an equivalent parasitic, transient resistance in ohms, appearing between the contact and the resistance element when the shaft is rotated or translated. The Equivalent Noise Resistance is defined independently of the resolution, the functional characteristics, and the total travel. The magnitude of the Equivalent Noise Resistance is the maximum departure from a specified reference line. The wiper of the potentiometer is required to be excited by a specified current and moved at a specified speed.

6.2 OUTPUT SMOOTHNESS (NONWIREWOUND POTENTIOMETERS ONLY):
Output Smoothness is a measurement of any spurious variation in the electrical output not present in the input. It is expressed as a percentage of the Total Applied Voltage and measured for specified travel increments over the Theoretical Electrical Travel. Output Smoothness includes effects of contact resistance variations, resolution and other micrononlinearities in the output.

6.3 RESOLUTION:
A measure of the sensitivity to which the Output Ratio of the potentiometer may be set.

6.4 THEORETICAL RESOLUTION (LINEAR WIREWOUND POTENTIOMETERS ONLY):
The reciprocal of the number of turns of wire in resistance winding in the Actual Electrical Travel, expressed as a percentage.

N = Total number of resistance wire turns.

$\frac{1}{N} \times 100$ = Theoretical Resolution percent.

6.5 TRAVEL RESOLUTION (WIREWOUND POTENTIOMETERS ONLY):
The maximum value of shaft travel in one direction per incremental voltage step in any specified portion of the resistance element.

6.6 VOLTAGE RESOLUTION:
The maximum incremental change in Output Ratio with shaft travel in one direction in any specified portion of the resistance element.

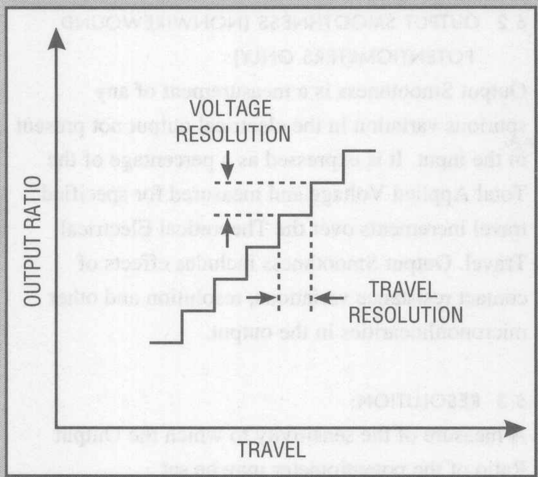


FIGURE 6.6 Wirewound resolution

Note: The illustration above is valid only for wirewound potentiometers because of the "stepped" nature of the output function. For determination of the effect of resolution in a nonwirewound potentiometer, refer to Output Smoothness (6.2).

6.7 DIELECTRIC WITHSTANDING VOLTAGE:

Ability to withstand under prescribed conditions, a specified potential of a given characteristic between the terminals of each cup and the exposed conducting surfaces of the potentiometer, or between the terminals of each cup and the terminals of every other cup in the gang without exceeding a specified leakage current value.

6.8 INSULATION RESISTANCE:

The resistance to a specified impressed DC voltage between the terminals of each cup and the exposed conducting surfaces of the potentiometer, or between the terminals of each cup and the terminals of every other cup in the gang, under prescribed conditions.

6.9 POWER RATING:

The maximum power that a potentiometer can dissipate under specified conditions while meeting specified performance requirements.

6.9.1 POWER DERATING:

The modification of the nominal power rating for various considerations such as Load Resistance, Output Slopes, Ganging, nonstandard environmental conditions and other factors.

6.10 LIFE:

The number of shaft revolutions or translations obtainable under specific operating conditions and within specified allowable degradations of specific characteristics.

7 AC CHARACTERISTICS

7.1 TOTAL INPUT IMPEDANCE:

The impedance between the two input terminals with open circuit between output terminals and measured at a specified voltage and frequency with the shaft positioned to give a maximum value.

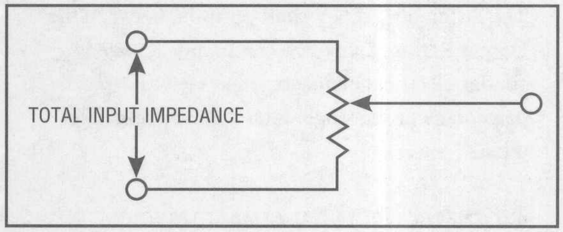


FIGURE 7.1 Total input impedance

7.2 OUTPUT IMPEDANCE:

Maximum impedance between slider and either end terminal with the input shorted, and measured at a specified voltage and frequency.

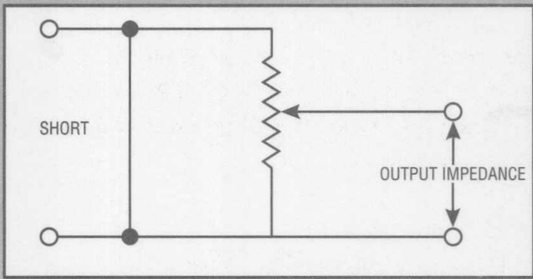


FIGURE 7.2 Output impedance

7.3 QUADRATURE VOLTAGE:

The maximum value of that portion of the output voltage which is ±90° out of time phase with the input voltage, expressed as volts per volt applied, measured at a specified input voltage and frequency.

7.4 PHASE SHIFT:

The phase difference, expressed in degrees, between the sinusoidal input and output voltages measured at a specified input voltage and frequency with the

MATHEMATICALLY: $\phi = \sin^{-1}(e_q/e) = \tan^{-1}(e_q/e_i)$

shaft at a specified position.

Where:

θ = phase shift in degrees

e_q = quadrature voltage

e_i = inphase output voltage

e = output voltage

8 MECHANICAL CHARACTERISTICS

8.1 SHAFT RUNOUT:

The eccentricity of the shaft diameter with respect to the rotational axis of the shaft, measured at a specified distance from the end of the shaft. The body of the potentiometer is held fixed and the shaft is rotated with a specified load applied radially to the shaft. The eccentricity is expressed in inches, TIR.

8.2 LATERAL RUNOUT:

The perpendicularity of the mounting surface with respect to the rotational axis of the shaft, measured on the mounting surface at a specified distance from the outside edge of the mounting surface. The shaft is held fixed and the body of the potentiometer is rotated with specified loads applied radially and axially to the body of the pot. The Lateral Runout is expressed in inches, TIR.

8.3 PILOT DIAMETER RUNOUT:

The eccentricity of the pilot diameter with respect to the rotational axis of the shaft, measured on the pilot diameter. The shaft is held fixed and the body of the potentiometer is rotated with a specified load applied radially to the body of the pot. The eccentricity is expressed in inches, TIR.

8.4 SHAFT RADIAL PLAY:

The total radial excursion of the shaft, measured at a specified distance from the front surface of the unit. A specified radial load is applied alternately in opposite directions at a specified point. Shaft Radial Play is expressed in inches.

8.5 SHAFT END PLAY:

The total axial excursion of the shaft, measured at the end of the shaft with a specified axial load supplied alternately in opposite directions. Shaft End Play is expressed in inches.

8.6 STARTING TORQUE:

The maximum moment in the clockwise and counterclockwise directions required to initiate shaft rotation anywhere in the Total Mechanical Travel.

8.7 RUNNING TORQUE:

The maximum moment in the clockwise and counterclockwise directions required to sustain uniform shaft rotation at a specified speed throughout the Total Mechanical Travel.

2

8.8 MOMENT OF INERTIA:

The mass moment of inertia of the rotating elements of the potentiometer about their rotational axis.

8.9 STOP STRENGTH

8.9.1 STATIC STOP STRENGTH:

The maximum static load that can be applied to the shaft at each mechanical stop for a specified period of time without permanent change of the stop positions greater than specified.

8.9.2 DYNAMIC STOP STRENGTH:

The inertia load, at a specified shaft velocity and a specified number of impacts, that can be applied to the shaft at each stop without a permanent change of the stop position greater than specified.

DESIGN AIDS

PRECISION NON-LINEAR POTENTIOMETERS

CERMET*, WIREWOUND AND CONDUCTIVE PLASTIC MODELS

Certain potentiometer applications require that the slider output voltage follow some predetermined non-linear function, as would be the case in employing a potentiometer to maintain a continuous balance between a non-linear mechanical drive and a linear bridge network. For such applications, BI Technologies manufactures non-linear potentiometers, identical to linear models in every way except for the resistance element. Non-linear models with outputs ranging from the simplest monotonic function to the most complex non-monotonic function can be supplied with either wirewound, cermet or conductive plastic resistance elements. Single-turn and multi-turn models are available in many different housing sizes and configurations.

CRITICAL NON-LINEAR PARAMETER

The critical parameter for any non-linear function is the maximum slope of the function. For rotating units:

$$\text{Slope} = \frac{de_o}{d\theta}$$

where: e_o = the output voltage
and: θ = the angular rotation

By convention, this equation can be written as:

$$\text{Slope} = \frac{dy}{dx}$$

Where: y = normalized voltage ratio $\left(\frac{\text{output voltage}}{\text{input voltage}}\right)$

And:
x = normalized shaft rotation $\left(\frac{\text{electrical travel}}{\text{theoretical electrical travel}}\right)$

Once the maximum slope is known, other parameters can be approximated by using the following:

1. To determine the best conformity obtainable, select the potentiometer model that fits the application's mechanical requirements. Then multiply the maximum slope times the minimum practical linearity available in that potentiometer.

2. To determine the maximum total resistance which can be obtained, divide the maximum total resistance available in the linear potentiometer model by the maximum slope of the function.

3. To determine the maximum power dissipation obtainable in a non-linear function, divide the power rating of the linear potentiometer model by the square root of the maximum slope of the function.

* Non-linear cermet potentiometers are available only in certain functions. Consult your local BI Technologies sales engineering representative for additional information.

PRACTICAL DESIGN DATA

Single-Turn Wirewounds	Nominal Diameter: 7/8" (22,225mm)	1 1/16" (26,975mm)	1 5/16" (33,325mm)	1 7/16" (36,500mm)	2" (50,800mm)	3" (76,200mm)
Min. Practical Linearity (±%)	0.15	0.12	0.10	0.08	0.07	0.05
Max. Total Resistance (ohms)	60K	100K	45K	50K	215K	145K
Power Rating (watts at 40°C)	1.25	1.50	1.50	3.50	3.50	5.00

Multi-Turn Wirewounds	Nominal Diameter and Rotation: 7/8" 1,800° (22,225mm)	7/8" 3,600° (22,225mm)	1 13/16" 1,080° (46,025mm)	1 13/16" 3,600° (46,025mm)	3 5/16" 5,400° (84,125mm)	3 5/16" 9,000° (84,125mm)
Min Practical Linearity (±%)	0.075	0.05	0.04	0.025	0.025	0.025
Max. Total Resistance (ohms)	63K	125K	190K	650K	2 meg	3.3 meg
Power Rating (watts at 40°C)	1.4	2.0	3.0	5.0	10.0	15.0

Single Turn Cermets	Nominal Diameter: 7/8" (22,225mm)	1 1/16" (26,975mm)	1 5/16" (33,325mm)	2" (50,800mm)
Min Practical Linearity (±%)	0.25	0.20	0.20	0.15
Max. Total Resistance (ohms)	1 meg	1 meg	1 meg	1 meg
Power Rating (watts at 85°C)	3.0	5.0	6.0	10.0

Single Turn Conductive Plastics	Nominal Diameter: 7/8" (22,225mm)	1 1/16" (26,975mm)	1 5/16" (33,325mm)	2" (50,800mm)
Min Practical Linearity (±%)	0.25	0.10	0.075	0.05
Max. Total Resistance (ohms)	100K	100K	100K	150K
Power Rating (watts at 70°C)	1.0	1.5	2.0	2.5

The tables list the minimum practical linearity, maximum total resistance and power rating for Helipot® linear potentiometers and are given for reference. These ratings can be used in the equations to approximate conformity, total resistance and power dissipation limits which can be provided in Helipot® non-linear potentiometers.

The methods given are for determining the best obtainable conformity and maximum resistance and do not include several other factors which influence the final values. These factors are:

1. Whether the function is monotonic or reversing.
2. Type of conformity required - absolute, proportional, ohmic, etc.
3. Whether the application requires a resistance function, as in rheostat usage, or a voltage function, as in potentiometric or voltage divider usage.
4. The length of the resistance coil in wirewound units, or the potentiometer diameter in cermet and conductive plastic units.
5. Whether the application requires a slider load.
6. Whether the input is AC or DC.

MONOTONIC AND REVERSING FUNCTIONS

A monotonic function is one where the slope is either positive or negative throughout the entire function.

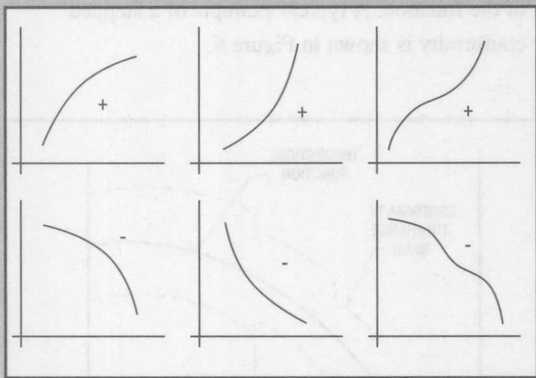


FIGURE 1. Monotonic Functions

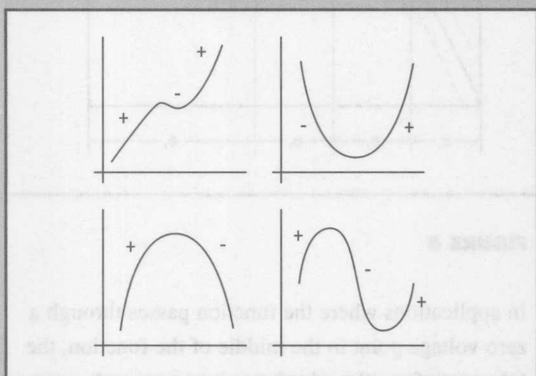


FIGURE 2. Reversing Function

BI Technologies' engineering personnel can provide specific electrical values, taking into consideration all factors, for any non-linear function and application.

CONFORMITY

Conformity is the fidelity of the relationship between the actual function characteristic and the theoretical function characteristic. In non-linear potentiometers, conformity can be specified as absolute conformity, proportional conformity or as stepped conformity. Absolute Conformity is the maximum deviation of the actual function characteristic from a fully defined theoretical function characteristic. It is expressed as a percentage of the total applied (input) voltage and measured over an absolute angle (theoretical electrical travel). This angle is defined by an index point usually located on the steepest slope area of the actual output. The index point may not coincide with the tap points. See Figure 3.

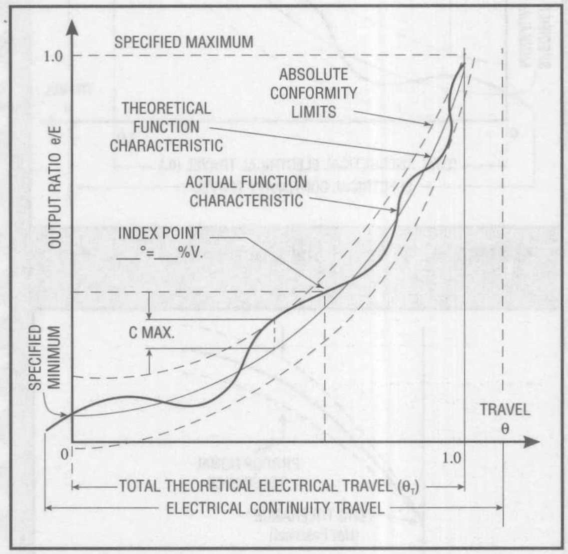


FIGURE 3. Absolute Conformity

Proportional Conformity is the maximum deviation of the actual function characteristic from a fully defined theoretical function characteristic. However, unlike absolute conformity, it is expressed as a percentage of the output voltage (see Figure 4). A true proportional conformity would be zero at the zero end of the function, as shown in Figure 5A. However, this is not practical and cannot be produced in a non-linear potentiometer. Figure 5B shows a modified proportional conformity where the conformity is a constant value over a small segment

of the theoretical function characteristic and is proportional to the output voltage over the balance of the function.

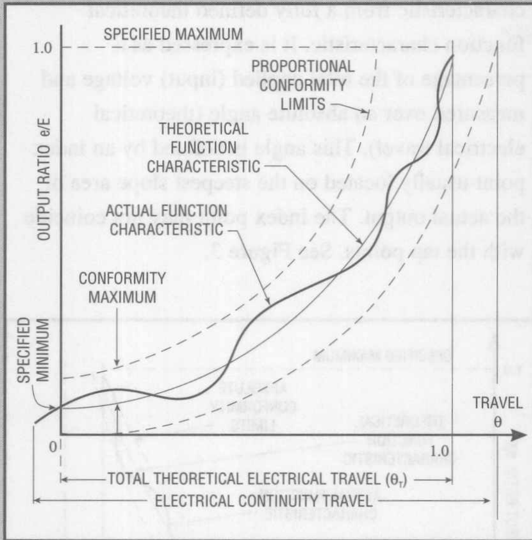


FIGURE 4. Proportional Conformity

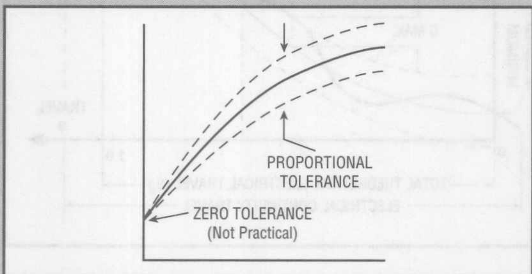


FIGURE 5A

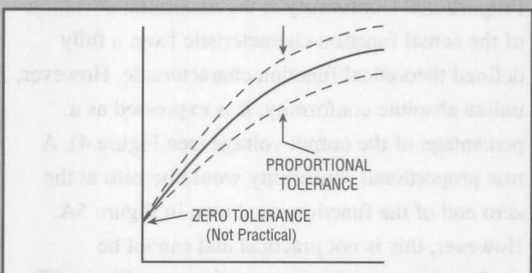


FIGURE 5B

STEPPED CONFORMITY

Another type of conformity sometimes used is stepped conformity, which is similar to proportional conformity in that closer tolerances are used only when needed. Tolerances are relaxed in other parts of the function. A typical example of a stepped conformity is shown in Figure 6.

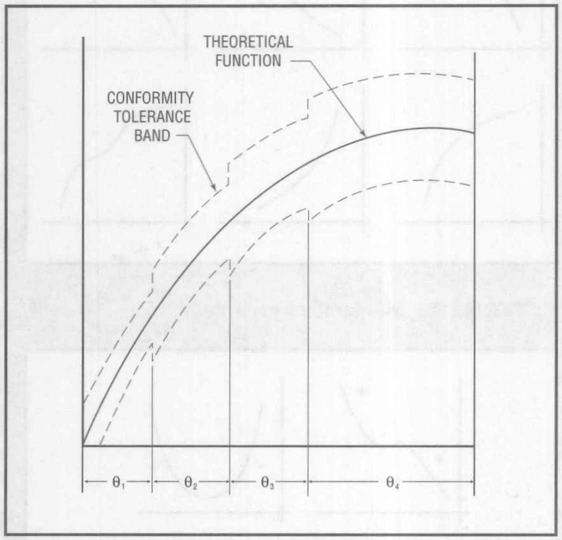


FIGURE 6

In applications where the function passes through a zero voltage point in the middle of the function, the tolerances for either absolute or proportional conformity can be specified in two ways (see Figure 7).

(1) Peak-to-peak tolerances - expressed as a percentage of the total input voltage; (2) Zero-to-peak tolerances - expressed as a percentage of one-half of the total input. For example, if the specified zero-to-peak conformity tolerance is ± 0.10%, the peak-to-peak conformity tolerance would be ±0.05%.

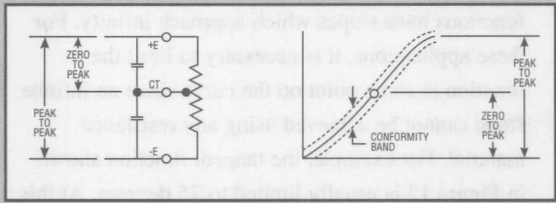


FIGURE 7

LOAD COMPENSATION

When a slider load is a part of the circuit, the effects of loading produces errors which must be compensated for so that when the load is applied, the output voltage will follow the desired function. The magnitude of the loading error is a function of the ratio of the slider load to the total resistance of the potentiometer. This error varies inversely with the load ratio. That is, a small load ratio will produce a large error. The following table gives the conformity error for various load ratios.

Load Ratio	Conformity Error
1:1	12.30%
2:1	6.74%
5:1	2.90%
10:1	1.45%
20:1	0.75%
50:1	0.30%
100:1	0.15%

A slider load may be applied to either end of a function, or to the center tap as shown in Figure 8.

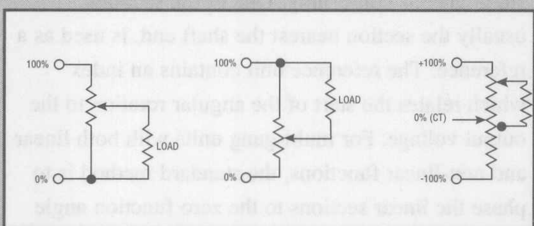


FIGURE 8

VOLTAGE DIVIDER AND RHEOSTAT APPLICATIONS

When a non-linear potentiometer is used as a three terminal device, as shown in Figure 9, the output voltage (e_{out}) is a function of the ratio of the resistance between the slider terminal and one end terminal, and the total resistance. Since it is a ratio, the total resistance does not affect the output voltage in potentiometric or voltage divider applications. An exception is when considerable slider current is drawn, for example, when there is very low load ratio.

When a non-linear potentiometer is used in a two terminal or rheostat application, the output of interest is the resistance between the slider and one end terminal, with the other end terminal unconnected. In these applications, conformity tolerance is generally expressed in ohms since the total resistance tolerance is a part of the conformity tolerance.

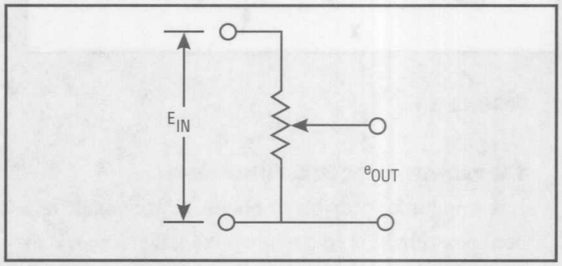


FIGURE 9. Voltage Divider

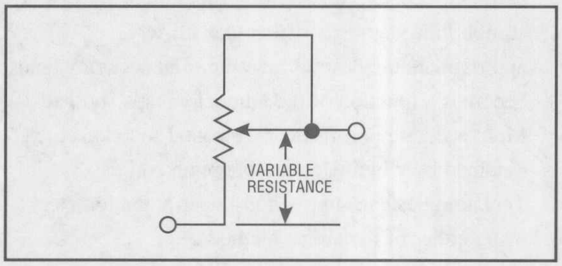


FIGURE 10. Rheostat

SLOPE RATIO

In addition to the maximum slope, the slope ratio of a non-linear function is also an important parameter. It is defined as the ratio of the maximum slope divided by the minimum slope (see Figure 11). Any function, where the minimum slope is zero, has an infinite slope ratio. BI Technologies can supply non-linear potentiometers with a minimum slope of zero. Although the total resistance of the unit is determined by the maximum slope and the rate of slope change over the part of the curve nearest the maximum slope, the slope ratio affects the accuracy.

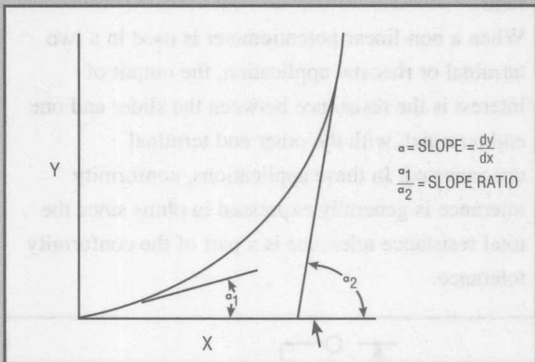


FIGURE 11

TAPPED AND PADDED FUNCTIONS

It is sometimes possible to obtain an acceptable non-nonlinear function in a wirewound potentiometer by tapping and padding a linear resistance element. This can be done only where tolerances are not extremely close. The resulting function is a series of straight line segments which may closely approximate the desired function. The accuracy then becomes a function of the number of taps and pads. More accurate non-linear wirewound functions are obtained by winding a variable pitch coil. BI Technologies can supply non-linear potentiometers using either of the above methods.

INFINITE SLOPE FUNCTIONS

Certain mathematical functions, such as tangents, secants, cosecants, square roots and inverse functions have slopes which approach infinity. For these applications, it is necessary to limit the function at some point on the curve since an infinite slope cannot be achieved using any resistance material. For example, the tangent function shown in Figure 12 is usually limited to 75 degrees. At this point, the slope ratio is 4:1. If the function is extended only 5 degrees more to 80 degrees, the slope ratio becomes 16:1. In general, the higher the maximum slope, the poorer the conformity and the lower the total resistance obtainable.

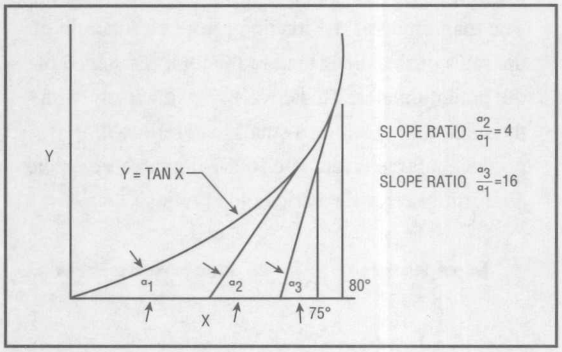


FIGURE 12

PHASING

When multi-gang units are required, attention must be given to the problem of phasing the functions with respect to one another. For units where all the sections are non-linear functions, the standard practice is to phase the sections to meet simultaneous conformity. One of the sections, usually the section nearest the shaft end, is used as a reference. The reference unit contains an index which relates the start of the angular rotation to the output voltage. For multi-gang units with both linear and non-linear functions, the standard method is to phase the linear sections to the zero function angle of the reference non-linear section. The index of the non-linear section defines the starting point.

Any combination of wirewound, cermet or conductive plastic non-linear or linear units can be ganged on a common shaft.

RESISTANCE ELEMENT SELECTION

Wirewound, cermet and conductive plastic resistance elements can be used for most mathematical or empirical non-linear functions. However, the requirements of the specific application can determine which type will provide the best performance and reliability. Wirewound elements offer maximum design flexibility and can be supplied in both multi-turn and single-turn models. In addition, they provide extremely low resistance change over a wide temperature range due to their low tempco. The maximum total resistance of wirewound models is limited primarily to values below 100K. Although the tempco may be 100 ppm/°C, cermets exhibit excellent resistance stability over a wide range of environments and can dissipate high power with little or no change in performance. In addition, cermet can be made with total resistances of several megohms. Conductive plastic units generally have better electrical noise characteristics, whether measured as ENR, output smoothness or by dither test. Life of a conductive plastic is greater than that of other types. Also, better conformities can be provided in conductive plastic than in cermets.

INFLUENCE OF RESISTOR ELEMENT ON POTENTIOMENTER CHARACTERISTICS

RATING:

1 Best

4 Good

ELEMENT TYPE	RESISTANCE RANGE	TEMPERATURE COEFFICIENT	BEST LINEARITY	SETTABILITY/RESOLUTION	NOISE OR CONTACT RESISTANCE VARIATION	ROTATIONAL LIFE	HIGH TEMPERATURE	RELATIVE COST
WIREWOUND	2	1	1	4	1	3	2	3
CONDUCTIVE PLASTIC	3	4	3	2	3	1	4	1
HYBRID (HIGH TEMP CP OVER WW COIL)	4	2	2	1	4	2	3	4
CERMET	1	3	4	3	2	4	1	2

NOTE: All element types are available in single turn units but only hybrid and wirewound are available in multiturn units.

GENERAL NOTES

1. Unless otherwise stated, all specifications are measured at room conditions (temperature 15°C to 35°C; air pressure 650 to 800 millimeters of mercury, relative humidity 45 to 75%).
2. Unless otherwise specified, all dimensions used in this catalog are in inches.
3. Standard tolerances for all drawings in this catalog are as follows:

   Fractional tolerance - ± 1/64" and ± 0.38mm
   Decimal tolerancing - XXX = ± .005"
   XX = ± .01"
   Angular tolerance- ± 2°
4. Metric equivalents, based on 1 inch = 25.4mm, are rounded to the same number of decimal places as in the original English units and are provided for general information only.
5. Noise specifications for all wirewound potentiometers listed in this catalog are stated at speeds up to 100 RPM with 1 milliamp of slider current unless otherwise specified.
6. All specifications, drawings and military specification information used in this catalog are subject to change without notice. Please check specification and drawing accuracy with your local BI Technologies representative prior to ordering.
7. A characteristic of most non-wirewound resistance elements is that the end points are difficult to locate precisely by direct measurement. Verification is made by extrapolating from the 1% and 99% voltage points.
8. HYBRID, infinite resolution, versions are also available.
9. Helipot and Helitrim are registered trademarks of BI Technologies.
10. References to parts per million (ppm) equal $p/10^6$.

RANGE OF APPLICATIONS

The versatility of the precision potentiometer is absolutely astounding. For more than 50 years, BI Technologies has provided technical and product leadership in this market and has supplied high quality precision potentiometers to an ever expanding array of applications. We are continually amazed at the application growth. The vast majority of our customer application efforts have resulted in a customized or modified potentiometer that has been created to serve a specific customer requirement. We are committed to provide this kind of customer service in a cost effective manner.

From the invention of the HELIPOT (multi-turn helical potentiometer) to the pioneering developments in CERMET and CONDUCTIVE PLASTIC element technologies, BI has remained at the forefront in new technical innovation. We welcome an opportunity to demonstrate our capabilities by solving one of your tough problems.

Some of the broad application categories that utilize precision potentiometers include:

- Heavy industrial equipment
- Automotive equipment
- Airborne equipment
- Process controls
- Electric vehicles
- Military and commercial aircraft
- Scientific equipment
- Electronic equipment
- Medical equipment
- Heating and air conditioning equipment

In general, the specific function of a precision potentiometer falls into one of the two categories below:

1. Position Sensors
2. Precision Controls

As a way of illustrating both applications and functions, the following lists are provided. These lists will illustrate the practical range of solutions that we have implemented with BI Precision Potentiometer products and engineering expertise.

AUTOMOTIVE/VEHICLES/HEAVY EQUIPMENT

This is a rapidly growing field in which vehicle manufacturers are quickly moving to take advantage of electronic controls, sensors and feedback systems. BI precision potentiometers can be found in:

- Handwheel (steering) position sensors
- Golf cart and other electrically driven vehicle speed controls
- Automotive fuel level sensors
- Heavy equipment speed controls
- Rapid transit speed controls
- Linkage position sensors

CONTROLLERS

Since their introduction, BI precision potentiometers have been an integral part of control systems. Their use has broadened to an enormous list of applications, such as:

- Oil field and refinery equipment
- Building heating and air conditioning controls
- Scientific and laboratory instrument controls
- Limit setting controls for blood pressure monitors
- Color controls for printing presses
- Music system amplifier controls
- Controls for gates in water treatment plants
- Table position controls for X-ray machines
- Theater lighting and stage controls
- Army tank gunsight controls
- Nuclear submarine propulsio controls

AVIONICS/AEROSPACE

The avionics and aerospace industry has required some of the most sophisticated precision potentiometers ever devised, and BI has been a leader in filling those needs. In virtually every case, a special product was required. Here are some examples:

- Air-to-air missile control surface feedback sensors
- Nose up/down attitude sensors for commercial and military aircraft
- Control surface position sensors
- Fluid level sensors
- Cabin environmental controls for commercial and military aircraft
- Ground equipment controls
- Service vehicle controls
- Helicopter flight controls
- Guided missile stage separation sensors
- Guidance control feedback sensors
- Communications system controls
- Aircraft lighting system controls

INSTRUMENTATION

In the field of instrumentation, proper control and analysis requires input from sensors, which are "near the action." BI precision potentiometers have been, and are, excellent choices for many such applications. Among other things, they are robust in design, dependable and accurate. Here is a brief list of BI sensors now in use:

- Ships roll indicator systems
- Hydrofoil rudder position feedback sensors
- Ships' tank level sensors
- Meteorological measuring equipment
- Gyro compass sensors
- Robotics position sensors
- X-Y plotter position sensors

APPLICATION CONSIDERATIONS

When specifying a precision potentiometer, bear in mind that potentiometer design is the result of a series of trade-offs that have proven most generally useful and widely acceptable. The potentiometer manufacturer can optimize your design based on your application and requirements. Furthermore, the manufacturer knows many materials not normally used - i.e., precious metals, special lubricants, etc. - which can solve problems for you if cognizant of all the details of the application.

ELECTRICAL CHARACTERISTICS

- Linear or nonlinear? If a nonlinear, has the function been adequately specified?
- Type of linearity or conformity (absolute, zero-base or independent) and accuracy? Absolute conformity is usually required for direct readout potentiometers. Independent is sufficient when trimmers are used. Is it a closed loop function? If so, express conformity tolerance as zero-to-peak or peak-to-peak.
- Resistance and tolerance? Is it clear between what terminals resistance is measured? Or should you specify open loop resistance? Does it include or exclude end trimmers? Can the potentiometer be shunted to get low resistance while maintaining good resolution? Can it be shunted by a very high resistance to meet a close resistance tolerance? Has the effect of wiper shorting been considered?
- When specifying resistance of sine/cosine potentiometers, specify the required resistance/quadrant (that is the effective resistance per quadrant after the loop is closed).
- What type (angular or voltage) and value resolutions are necessary?
- What noise is tolerable in the system? Can certain frequencies be excluded in measuring noise or can sharp spikes of short duration be permitted (or filtered out)? Is the standard noise test pertinent or do you need a different one? At what speed should it be run?
- Have you considered the effect wiper load is going to have on output accuracy? Manufacturers can compensate for most loads and achieve any desired accuracy more easily than you can.
- Are special taps needed? Are they to be used as voltage reference points (voltage tap) or as input points (current tap)? How are they to be located voltage-wise relative to the index point? Relative to mechanical stops? Relative to end taps (standard)?
- What is the electrical angle? How is it related to the required function? To the electrical angles or functions in other sections (phasing)? Is overtravel necessary? How is it related to the mechanical angle?
- Is end resistance critical? Should it be measured by resistance or voltage (a resistance measurement includes wiper circuit resistance, which a voltage measurement does not)? Should measurement be at the point of minimum resistance or voltage (standard) or at the stop (special)?
- What voltage is applied? How much current will flow through contact? Is this a rheostat application? What power is dissipated?
- What maximum dielectric strength is desirable? At sea level or what altitude?
- Is temperature coefficient of resistance important? Must it be matched to fixed resistors? Over what temperature range?
- Are AC characteristics important? Quadrature voltage? Capacitive reactance? Other? At what frequency? At what wiper setting? Measured between what points?
- How much backlash is tolerable?

MECHANICAL CONSIDERATIONS

- Weldable or solderable terminals? What size (diameter, length) and weights are permissible?
- What type of mounting-servo, bushing, locking bushing, three-hole? A no-turn lug is usually advisable on a bushing mount. Will the bushing length specified satisfy your maximum panel thickness with all hardware in place?
- What kind of shaft-splined, flatted, slotted? Must special diameter, length or shoulder be considered? What runout is permissible relative to mounting surface?
  Note: Potentiometer manufacturers do not recommend machining operations on the shaft after assembly.
- What materials are required for housing, shaft, terminals, etc.?
- Is there a shaft load or a speed requirement that necessitates ball bearings or is a sleeve bearing satisfactory? Is there an axial load on the shaft?
- Lateral runout, pilot diameter runout, shaft end play, radial play?
- Are stops required? What strength must they have? Does the application require a static or dynamic load? (Avoid using potentiometer stops for anything but emergency use; provide system stops.) What mechanical angle and tolerance necessary?
- If there is more than one section, must they be phasable in the field?
- Any special terminals or terminal locations required?
- Is very high or very low operating torque required? At room temperature or over a range of temperatures?
- Is special marking required? Fungus treatment?

OPERATING CONSIDERATIONS

- How many shaft revolutions will be required? At what rpm? To what value may any of the original electrical or mechanical requirements be permitted to degrade? Is the rotation continuous (over the bridge)? In one direction? Will there be a problem with dither?
- What is the operating temperature range? How much can the original requirements change over this temperature range?
- Are there other special operating conditions such as humidity, vibration, shock acceleration or altitude?

TESTING CONSIDERATIONS

- What acceptance testing is necessary? What documentation? Source inspection? Certification? Traceability? Would it pay to "burn-in" units to eliminate infant mortality?
- What qualification test information is necessary?
- In each case have the criteria for failure been specified?
- Is failure mode parametric or catastrophic?

GENERAL

Much of this information never appears on procurement documents. This is unfortunate because the potentiometer manufacturer can choose more wisely and economically among the factors that influence potentiometer performance if thoroughly aware of the application. If you are unsure about your requirements, please don't hesitate to call and discuss your requirements with one of our B.I. Technologies application engineers.

BI Precision Potentiometers and Duodial® turns counting dials are available from BI sales engineering representatives in the United States,

Canada and throughout the world. Many models are stocked locally, ready for immediate off-the-shelf delivery.

To order a precision potentiometer:

1. Select the BI wirewound, conductive plastic hybrid or cermet precision potentiometer model which best suits your specific application.

2. Specify the basic model number (example: Model 7286). This would be a 7⁄8" diameter, 10-turn wirewound unit with bushing mount and sleeve bearing.

3. Add to the basic model number "R," followed by the specific resistance value required (example: Model 7286 R10K). This specifies a 10,000 ohm total resistance. Model 7286 R100 would be for a 100 ohm total resistance.

4. Unless otherwise specified, the standard resistance tolerance for the model ordered will be assumed. If another resistance tolerance is desired, place the desired value, in parentheses, following the total resistance value (example: Model 7286 R10K (1)). This specified a ± 1% tolerance.

5. To specify a linearity, add the letter "L" after the resistance value or non-standard resistance tolerance followed by the desired linearity (example: Model 7286 R10K L.25 would refer to a linearity of ± 0.25%).

6. Complete ordering information should include:
Example:
7286R – 10K – L.25
(Model – Resistance Value – Linearity)

7. Special coded features are available on most precision pots. Coded features include: center taps, flatted and slotted shafts, linearity tape, rear shaft and shaft locks. These coded features require no special engineering and only a modest increase in potentiometer price. Check with your local BI Technologies sales engineering representative for additional information and cost for the model you wish to order.

CUSTOM CAPABILITIES

ROTARY MOTION PRECISION POTENTIOMETERS

BI Technologies single and multi-turn precision potentiometers offer compact size and high precision with a very wide range of special features:

- Industrial and MIL grade construction
- Linearity 0.25% is standard; reduced tolerances available to suit application requirements.
- Resistance tolerance to 1%.
- Wirewound or hybrid elements.
- Housing manufactured from metallic, phenolic or plastic materials.
- Special shaft configurations to suit application requirements.
- Multiple potentiometer outputs to suit application requirements.
- Several potentiometers can be ganged on a single shaft. Each section can have any value of linearity, resistance or other special feature that will suit the application requirements.

OIL-FILLED PRECISION POTENTIOMETERS

A special version of the rotary precision potentiometer that is designed for longer life in hostile environments. Most BI potentiometer specifications can be provided in an oil-filled configuration that will suit the specific application.

RECTILINEAR PRECISION POTENTIOMETERS

Rectilinear precision potentiometers are designed to provide a direct transfer of line motion to a proportional electrical output. BI rectilinear precision potentiometers offer:

- Stroke lengths from 1⁄2" to 6" (12mm to 150mm); other sizes on special order.
- Industrial or MIL grade construction.
- Linearity 0.5% is standard; reduced tolerances available to suit application requirements.
- Conductive plastic, wirewound or hybrid elements.
- Housings sealed against contaminants; metallic construction is standard; non-metallic housings are available on special order.
- Special shaft configurations to suit application requirements.

MOTORIZED PRECISION POTENTIOMETERS

Motorized potentiometers are ideally suited to a wide variety of industrial applications, such as automatic remote controls and readouts, servo-feedback and other analog functions. A precision potentiometer, motor, gearhead and clutch are precisely matched to provide optimum performance and reliability in a compact and economical unit. Motors can be supplied as AC, DC, DC torque, servo, stepper or synchronous to suit the specific application. Most BI potentiometer specifications (linearity, resistance, materials of construction, etc.) can be provided in a motor-driven configuration.

CONTROL SYSTEMS AND ELECTRONIC ASSEMBLIES

The Special Products Group is an experienced and versatile engineering team that designs special control systems and custom electronic assemblies. Our designs can be based on servo-devices or any other current technology.

The Special Products Group includes a sophisticated job shop. Systems or assemblies designed by our engineering team can be simulated, prototyped, assembled or manufactured and tested in-house. This Special Products Group's design/build capability was specifically created to solve individual customer requirements . . . quickly and efficiently.

Turns Counting Dials

3

Pot Models	Model Series RB			Model Series 2126	Model Series 2100/2200		Model Series 2600/2600S		Model Series 2620		Model Series 2640/2640S	
	RB RBC RBD	RBB	RBJ	2126	2157 2167	2257 2267	2601	2606 2607 2606S 2607S	2621	2626 2627	2641	2646 2647 2646S 2647S
A	✓			✓	✓	✓		✓		✓		✓
B		✓										
C	✓			✓	✓	✓		✓		✓		✓
7216	✓			✓	✓	✓		✓		✓		✓
7221			✓				✓		✓		✓	
7246	✓			✓	✓	✓		✓		✓		✓
7276	✓			✓	✓	✓		✓				
7281			✓				✓					
7286	✓			✓	✓	✓				✓		✓
7381			✓								✓	
7386	✓			✓	✓	✓				✓		✓
7481			✓				✓		✓		✓	
7486	✓			✓	✓	✓		✓		✓		✓
7601	✓			✓	✓	✓		✓		✓		✓
8136	✓			✓	✓	✓		✓		✓		✓
8141			✓				✓		✓		✓	
8146	✓			✓	✓	✓		✓		✓		✓
9301	✓			✓	✓	✓		✓		✓		✓

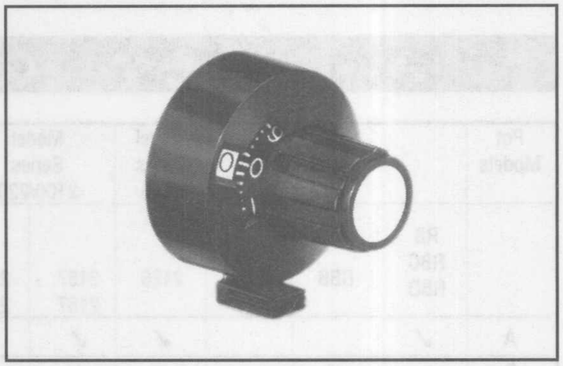
MODEL SERIES 2620

1″ Diameter

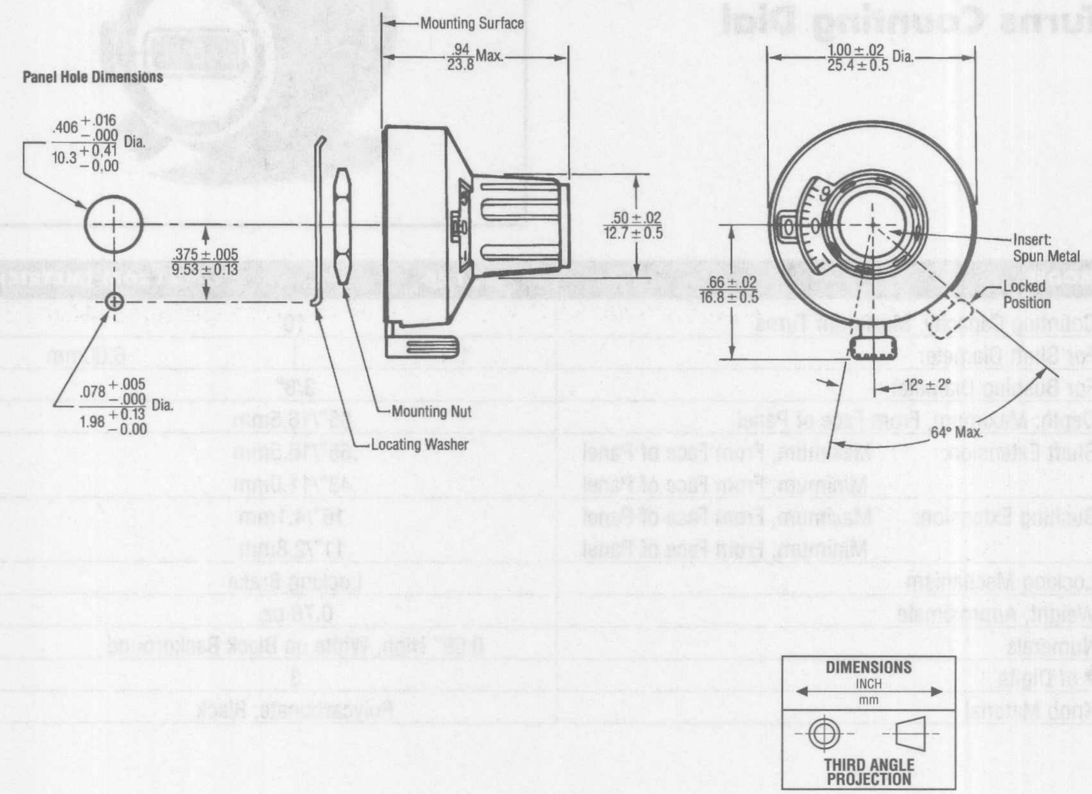
Analog

Turns Counting Dial

Distributor Item



MODEL SERIES		2626	2627
Counting Capacity, Maximum Turns		10	
For Shaft Diameter		1/4"	
For Bushing Diameter		3/8"	
Depth: Maximum, From Face of Panel		0.940"	
Shaft Extension:	Maximum, From Face of Panel	0.812"	
	Minimum, From Face of Panel	0.620"	
Bushing Extension: Maximum, From Face of Panel		0.335"	
Locking Mechanism		Positive Action	
Weight, Nominal		0.35 oz.	
Number of Set Screws		1	2
Numeral Height		0.090"	
Knob Material		Black Plastic	
Primary Dial Finish		White Numerals on Black	
Secondary Dial Finish		Black Numerals on White	
Housing Finish		Black Plastic	
Operating Temperature Range		-55°C to +71°C	


Mounting Surface
.94 / 23.8 Max.
Panel Hole Dimensions
.406 +.016 −.000 / 10.3 +0.41 −0.00 Dia.
.375 ± .005 / 9.53 ± 0.13
.078 +.005 −.000 / 1.98 +0.13 −0.00 Dia.
Mounting Nut
Locating Washer
.50 ± .02 / 12.7 ± 0.5
1.00 ± .02 / 25.4 ± 0.5 Dia.
.66 ± .02 / 16.8 ± 0.5
Insert: Spun Metal
Locked Position
12° ± 2°
64° Max.
DIMENSIONS
INCH
mm
THIRD ANGLE PROJECTION

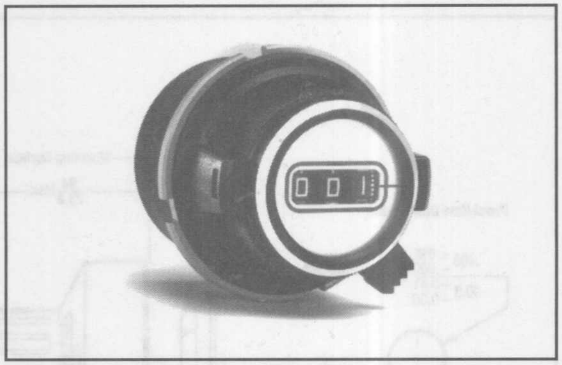
MODEL 2126

Distributor Item

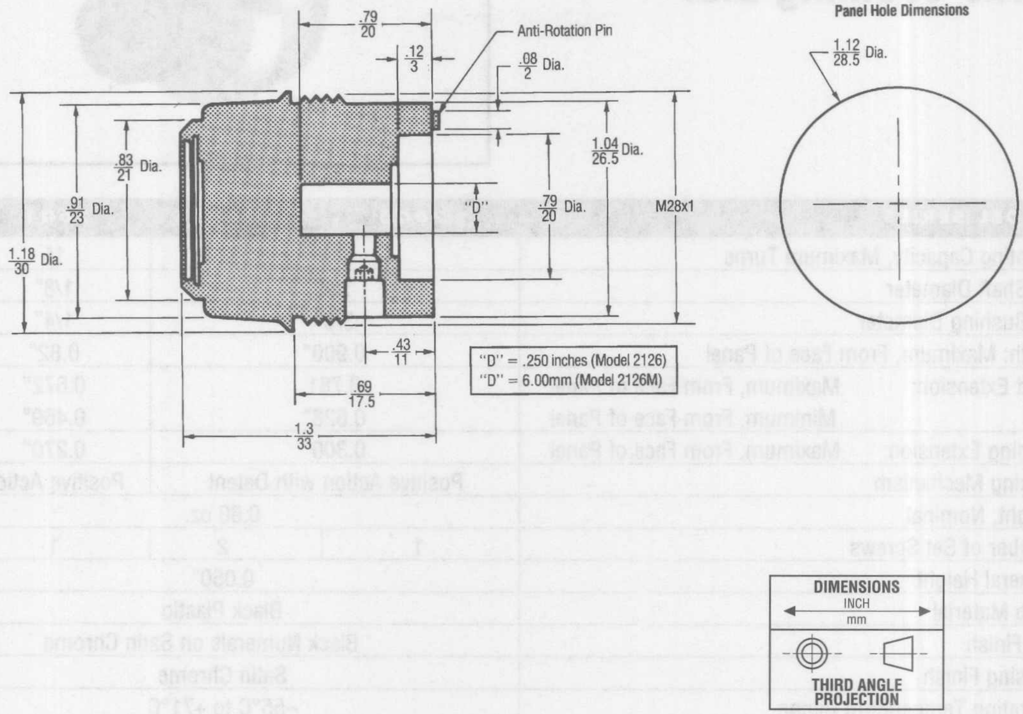
1" Diameter

Digital

Turns Counting Dial



MODEL		2126	2126M (METRIC)
Counting Capacity, Maximum Turns		10	
For Shaft Diameter		1/4"	6.00mm
For Bushing Diameter		3/8"	
Depth: Maximum, From Face of Panel		.65"/16.5mm	
Shaft Extension:	Maximum, From Face of Panel	.65"/16.5mm	
	Minimum, From Face of Panel	.43"/11.0mm	
Bushing Extension:	Maximum, From Face of Panel	.16"/4.1mm	
	Minimum, From Face of Panel	.11"/2.8mm	
Locking Mechanism		Locking Brake	
Weight, Approximate		0.76 oz.	
Numerals		0.09" High, White on Black Background	
# of Digits		3	
Knob Material		Polycarbonate, Black	


.79 / 20
.12 / 3
Anti-Rotation Pin
.08 / 2 Dia.
.83 / 21 Dia.
.91 / 23 Dia.
1.18 / 30 Dia.
"D"
.79 / 20 Dia.
1.04 / 26.5 Dia.
M28x1
.43 / 11
.69 / 17.5
1.3 / 33
"D" = .250 inches (Model 2126)
"D" = 6.00mm (Model 2126M)
Panel Hole Dimensions
1.12 / 28.5 Dia.
DIMENSIONS
INCH
mm
THIRD ANGLE PROJECTION

3

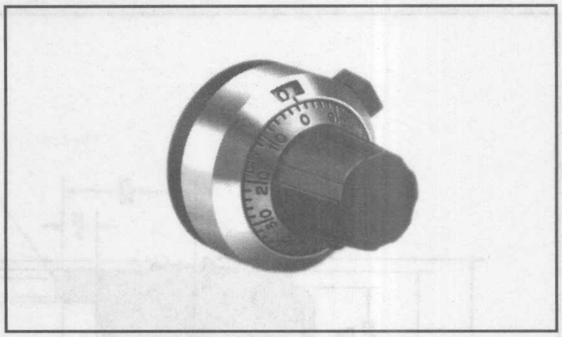
MODEL SERIES 2600

Distributor Item

7/8" Diameter

Analog

Turns Counting Dial

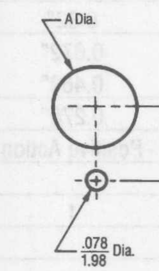


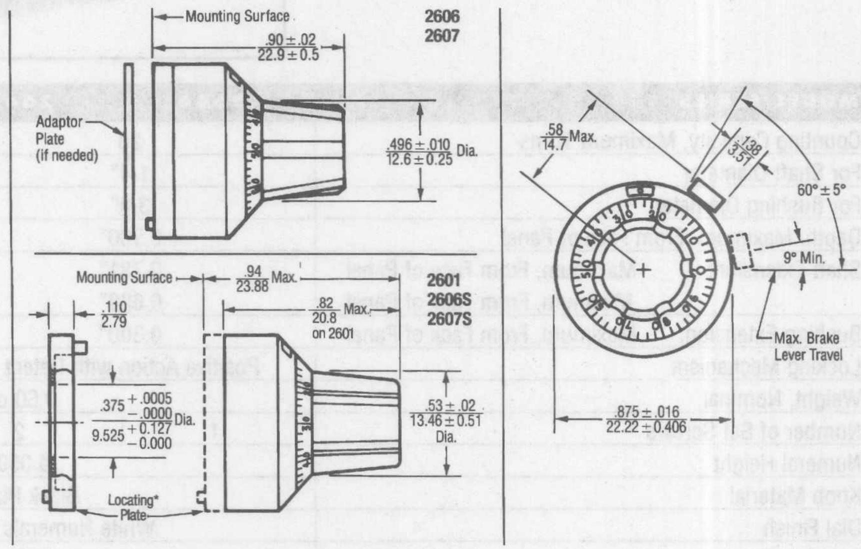
MODEL SERIES		2606	2607	2601
Counting Capacity, Maximum Turns		20		15
For Shaft Diameter		1/4"		1/8"
For Bushing Diameter		3/8"		1/4"
Depth: Maximum, From Face of Panel		0.900"		0.82"
Shaft Extension:	Maximum, From Face of Panel	0.781		0.672"
	Minimum, From Face of Panel	0.628"		0.469"
Bushing Extension:	Maximum, From Face of Panel	0.300"		0.270"
Locking Mechanism		Positive Action with Detent		Positive Action
Weight, Nominal		0.60 oz.		
Number of Set Screws		1	2	1
Numeral Height		0.050"		
Knob Material		Black Plastic		
Dial Finish		Black Numerals on Satin Chrome		
Housing Finish		Satin Chrome		
Operating Temperature Range		–55°C to +71°C		

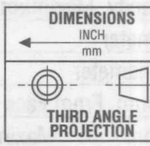
		2606S	2607S
Counting Capacity, Maximum Turns		15	
For Shaft Diameter		1/4"	
For Bushing Diameter		3/8"	
Depth: Maximum, From Face of Panel		0.94"	
Shaft Extension:	Maximum, From Face of Panel	0.781"	
	Minimum, From Face of Panel	0.578"	
Bushing Extension:	Maximum, From Face of Panel	0.300"	
Locking Mechanism		Positive Action	
Weight, Nominal		0.60 oz.	
Number of Set Screws		1	2
Numeral Height		0.050"	
Knob Material		Black Plastic	
Dial Finish		Black Numerals on Satin Chrome	
Housing Finish		Satin Chrome	
Operating Temperature Range		–55°C to +71°C	

Nominal Panel Hole Dimensions

Model	Dim. A	Dim. B
2601	.281 7.14	.281 7.14
2606, 2607, 2606S & 2607S	.406 10.3	.375 9.53



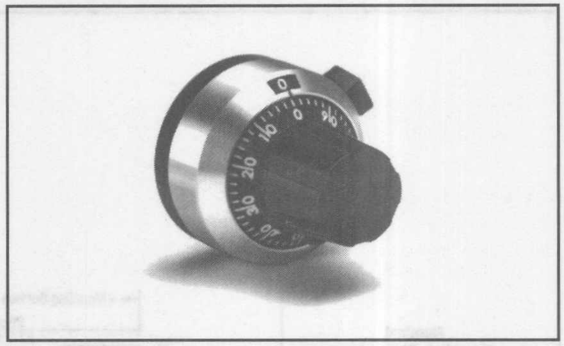




MODEL SERIES 2640

Distributor Item

7/8" Diameter
Analog
Turns Counting Dial

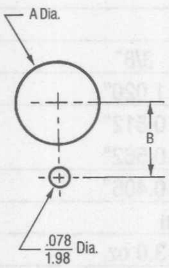


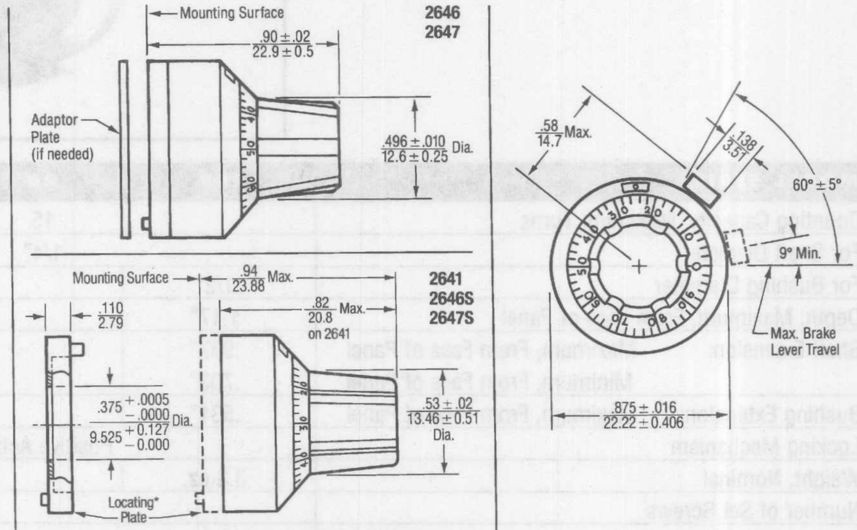
MODEL SERIES		2646	2647	2641
Counting Capacity, Maximum Turns		20		15
For Shaft Diameter		1/4"		1/8"
For Bushing Diameter		3/8"		1/4"
Depth: Maximum, From Face of Panel		0.900"		0.82"
Shaft Extension:	Maximum, From Face of Panel	0.781"		0.672"
	Minimum, From Face of Panel	0.628"		0.469"
Bushing Extension:	Maximum, From Face of Panel	0.300"		0.270"
Locking Mechanism		Positive Action with Detent		Positive Action
Weight, Nominal		0.60 oz.		
Number of Set Screws		1	2	1
Numeral Height		0.050"		
Knob Material		Black Plastic		
Dial Finish		White Numerals on Black Matte		
Housing Finish		Satin Chrome		
Operating Temperature Range		–55°C to +71°C		

		2646S	2647S
Counting Capacity, Maximum Turns		15	
For Shaft Diameter		1/4"	
For Bushing Diameter		3/8"	
Depth: Maximum, From Face of Panel		0.94"	
Shaft Extension:	Maximum, From Face of Panel	0.781"	
	Minimum, From Face of Panel	0.578"	
Bushing Extension:	Maximum, From Face of Panel	0.300"	
Locking Mechanism		Positive Action	
Weight, Nominal		0.60 oz.	
Number of Set Screws		1	2
Numeral Height		0.050"	
Knob Material		Black Plastic	
Dial Finish		White Numerals on Black Matte	
Housing Finish		Satin Chrome	
Operating Temperature Range		–55°C to +71°C	

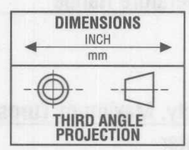
Nominal Panel Hole Dimensions

Model	Dim. A	Dim. B
2641	.281 / 7.14	.281 / 7.14
2646, 2647, 2646S & 2647S	.406 / 10.3	.375 / 9.53





*Model 2641 supplied with locating washer instead of locating plate.



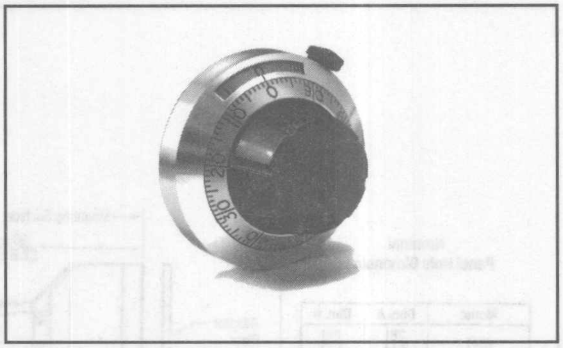
MODEL SERIES RB

Distributor Item

1-13/16" Diameter

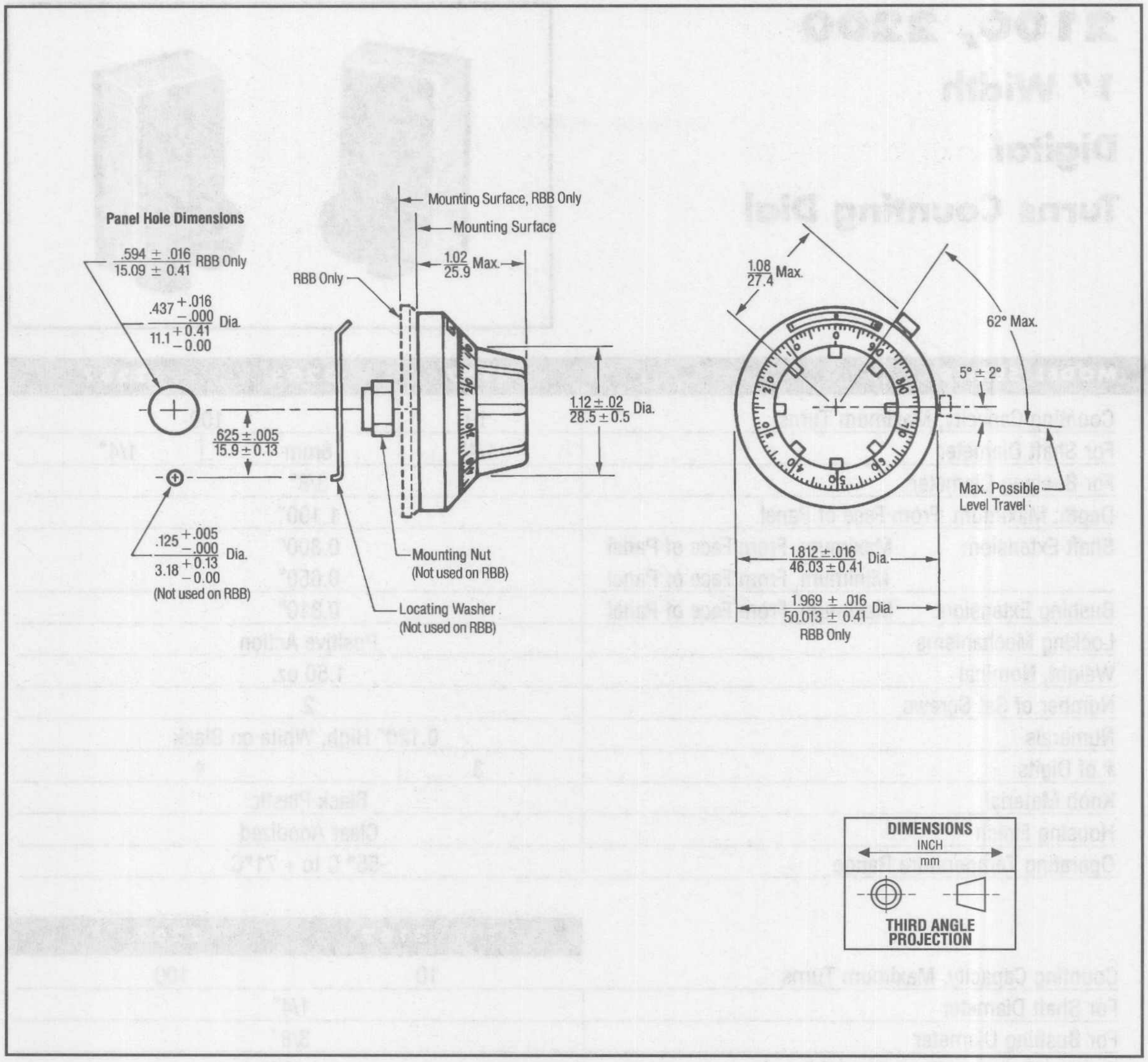
Analog

Turns Counting Dial



MODEL SERIES	RBB	RB	RBC
Counting Capacity, Maximum Turns		15	
For Shaft Diameter		1/4"	
For Bushing Diameter	1/2"	3/8"	
Depth: Maximum, From Face of Panel	1.17"	1.020"	
Shaft Extension: Maximum, From Face of Panel	.937"	0.812"	
Shaft Extension: Minimum, From Face of Panel	.703"	0.562"	
Bushing Extension: Maximum, From Face of Panel	.531"	0.406"	
Locking Mechanism		Positive Action	
Weight, Nominal	3.3 oz.	3.0 oz.	
Number of Set Screws	1		2
Numeral Height		0.100"	
Knob Material		Black Plastic	
Dial Finish		Black Numerals on Satin Chrome	
Housing Finish		Satin Chrome	
Operating Temperature Range		–55°C to +71°C	

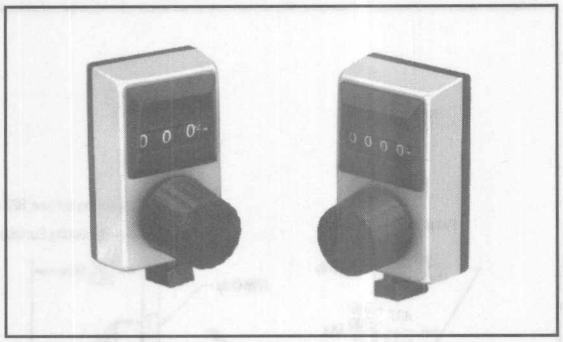
	RBD	RBJ
Counting Capacity, Maximum Turns	15	
For Shaft Diameter	1/4"	1/8"
For Bushing Diameter	3/8"	1/4"
Depth: Maximum, From Face of Panel	1.020"	
Shaft Extension: Maximum, From Face of Panel	0.812"	
Shaft Extension: Minimum, From Face of Panel	0.562"	
Bushing Extension: Maximum, From Face of Panel	0.406"	0.297"
Locking Mechanism	Positive Action	
Weight, Nominal	3.0 oz.	
Number of Set Screws	1	
Numeral Height	0.100"	
Knob Material	Black Plastic	
Dial Finish	White Numerals on Black Matte	Black Numerals on Satin Chrome
Housing Finish	Black Matte	Satin Chrome
Operating Temperature Range	–55°C to +71°C	



Panel Hole Dimensions
.594 ± .016 / 15.09 ± 0.41 RBB Only
.437 +.016 −.000 / 11.1 +0.41 −0.00 Dia.
.625 ± .005 / 15.9 ± 0.13
.125 +.005 −.000 / 3.18 +0.13 −0.00 Dia.
(Not used on RBB)
Mounting Surface, RBB Only
Mounting Surface
1.02 / 25.9 Max.
RBB Only
1.12 ± .02 / 28.5 ± 0.5 Dia.
Mounting Nut
(Not used on RBB)
Locating Washer
(Not used on RBB)
1.08 / 27.4 Max.
62° Max.
5° ± 2°
Max. Possible Level Travel
1.812 ± .016 / 46.03 ± 0.41 Dia.
1.969 ± .016 / 50.013 ± 0.41 Dia.
RBB Only
DIMENSIONS
INCH
mm
THIRD ANGLE PROJECTION

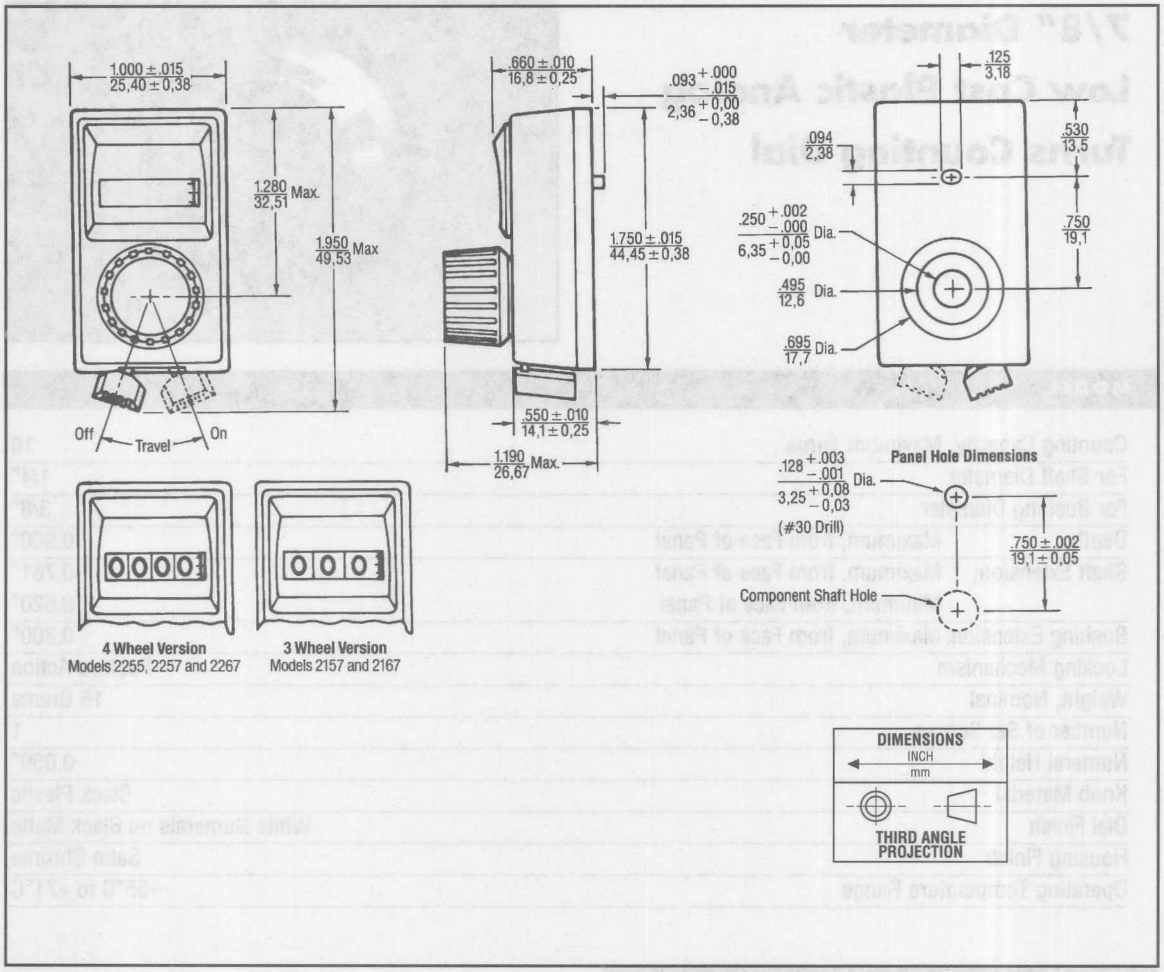
MODEL SERIES
2100, 2200
1" Width
Digital
Turns Counting Dial

Distributor Item



MODEL SERIES		2157	2255	2257
Counting Capacity, Maximum Turns		10	100	
For Shaft Diameter		1/4"	6mm	1/4"
For Bushing Diameter		3/8"		
Depth: Maximum, From Face of Panel		1.190"		
Shaft Extension:	Maximum, From Face of Panel	0.800"		
	Minimum, From Face of Panel	0.650"		
Bushing Extension:	Maximum, From Face of Panel	0.310"		
Locking Mechanisms		Positive Action		
Weight, Nominal		1.50 oz.		
Number of Set Screws		2		
Numerals		0.120" High, White on Black		
# of Digits		3	4	
Knob Material		Black Plastic		
Housing Finish		Clear Anodized		
Operating Temperature Range		-55° C to + 71°C		

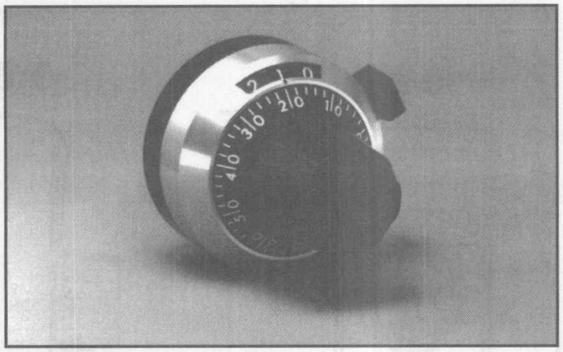
		2167	2267
Counting Capacity, Maximum Turns		10	100
For Shaft Diameter		1/4"	
For Bushing Diameter		3/8"	
Depth: Maximum, From Face of Panel		1.190"	
Shaft Extension:	Maximum, From Face of Panel	0.800"	
	Minimum, From Face of Panel	0.650"	
Bushing Extension:	Maximum, From Face of Panel	0.310"	
Locking Mechanisms		Positive Action	
Weight, Nominal		1.50 oz.	
Number of Set Screws		2	
Numerals		0.120" High, White on Black	
# of Digits		3	4
Knob Material		Black Plastic	
Housing Finish		Black Anodized	
Operating Temperature Range		-55° C to + 71°C	


1.000 ± .015
25,40 ± 0,38
1.280 Max.
32,51
1.950 Max
49,53
Off
Travel
On
.660 ± .010
16,8 ± 0,25
.093 +.000 −.015
2,36 +0,00 −0,38
1.750 ± .015
44,45 ± 0,38
.550 ± .010
14,1 ± 0,25
1.190 Max.
26,67
.125
3,18
.530
13,5
.094
2,38
.250 +.002 −.000 Dia.
6,35 +0,05 −0,00
.750
19,1
.495 Dia.
12,6
.695 Dia.
17,7
Panel Hole Dimensions
.128 +.003 −.001 Dia.
3,25 +0,08 −0,03
(#30 Drill)
.750 ± .002
19,1 ± 0,05
Component Shaft Hole
0000
000
4 Wheel Version
Models 2255, 2257 and 2267
3 Wheel Version
Models 2157 and 2167
DIMENSIONS
INCH
mm
THIRD ANGLE PROJECTION

3

MODEL 2696

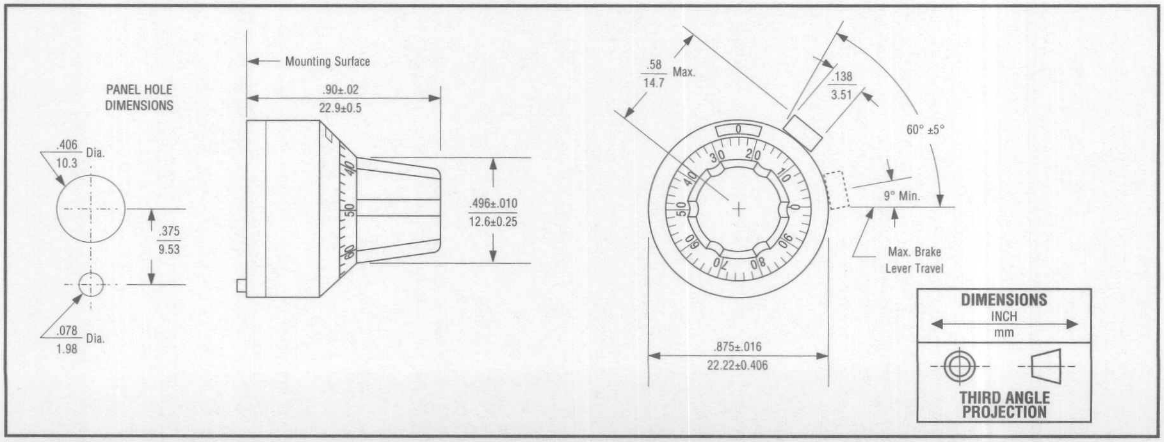
7/8" Diameter
Low Cost Plastic Analog
Turns Counting Dial



MODEL

Counting Capacity, Maximum Turns		10
For Shaft Diameter		1/4"
For Bushing Diameter		3/8"
Depth:	Maximum, from Face of Panel	0.900"
Shaft Extension:	Maximum, from Face of Panel	0.781"
	Minimum, from Face of Panel	0.620"
Bushing Extension:	Maximum, from Face of Panel	0.300"
Locking Mechanism		Positive Action
Weight, Nominal		16 Grams
Number of Set Screws		1
Numeral Height		0.050"
Knob Material		Black Plastic
Dial Finish		White Numerals on Black Matte
Housing Finish		Satin Chrome
Operating Temperature Range		–55°C to +71°C

MODEL 2696



Passive Networks

4

Resistor Networks
Capacitor Networks
Resistor Capacitor Networks
Diode Networks

NETWORKS

TECHNOLOGY	SMD NETWORK	CHIP	SIP	DIP	DESCRIPTION	APPLICATION
Precision Thin Film	660 Series				8/14/16 pin, 0.150" wide SOIC gull-wing	Amplifier gain setting, accurate attenuator voltage divider.
	NQS Series				16, 20 and 24 pin dual in line QSOP package 0.150" wide and 25 mil pitch	Amplifier gain setting, accurate attenuator voltage divider, pull up/ pull down and line termination.
	688				16 pin 0.300" wide gull-wing	Same, but for high resistance values.
	688V100				16 pin 0.300" wide gull-wing package	Voltage divider network for P6 (Pentium processor) power supply module; designed in conjunction with Linear Technology voltage regulator LTC 1430 leadless.
		BCT			0805, 1206 ± 0.1%, ± 25ppm/°C discrete chip resistors	Compact, surface mount precision alternative to leaded resistor.
				690 Series	8/14/16 pin thru-hole DIP	Same as 660.
Cost Effective Thick Film	620 Series				14/16 pin 0.220" wide gull-wing	General purpose pull up/ down, line termination and current limit uses.
	627T500/ 1250				14 pin 0.220" medium body gull-wing package	CCITT V.35 termination network; designed in conjunction with Linear Technology V.35 transceiver IC LTC:1345.
	627V100				14 pin 0.220" medium body gull-wing package	Voltage divider network for P5 (Pentium processor) power supply module; designed in conjunction with Linear Technology voltage regulator LTC 1584/1585.
	628L				16 pin R/2R ladder 0.220" wide network	Low cost DAC and attenuation applications.
	BCN				4/8/10 terminal leadless ceramic chip networks	Same applications as 620, but where space is at a premium.
		BCR			0402, 0603, 0805, 1206, 1210, 2010, 2512 Avail Tol.: ±0.5%, ±1%, ±2% & ±5%	Industry standard thick film chips for universal application.

TECHNOLOGY	SMD NETWORK	CHIP	SIP	DIP	DESCRIPTION	APPLICATION
Cost Effective Thick Film (Continued)			L Series		4 to 10 pin conformal SIP Tol.: ±2%, 0.195" max height	General purpose, pull up/down, line termination, and current limit uses.
			M Series		4 to 10 pin economical conformal SIP Tol.: ±5%, 0.195" max height	General purpose pull up/down, line termination, and current limit uses.
			T Series		Ultra-low profile conformal 0.140" max height	Same as L, but for height critical packaging.
			BH Series		High power conformal	For circuits where power dissipation is an important issue. Rated at 0.250W to 0.400W per resistor.
			BHV Series		High voltage, high value	For use in high voltage dividers, bleeder circuits, CRT flyback transformers.
		BPC Series			Non inductive planar thick film power resistor 3, 5, 7.5 & 10 watts	Inrush current limiters, preload circuits & snubber circuits.
				880	18/20 pin CERDIP	Ideal for multi-line termination; e.g. SCSI.
				890	14/16 pin CERDIP	General purpose pull up/down, line termination, and current limit uses.
				898L	8 and 10 bit R/2R ladder	Low cost DAC and attenuator applications.
Integrated R/C Networks		RC3/ RC4			0805, 1206 single chip R/C networks	Ideal for space critical AC termination and noise filtering applications.
	RC6				2512 leadless multiple circuit R/C network	
			C Series		Conformal capacitor SIP network	Efficient solution wherever multiple capacitors are required.
			CR Series		Conformal R/C SIP network	AC termination and noise filtering applications.
				890 (Custom)	R/C CERDIP 14/16/18/20 pin packages	Timing circuits, filters, AC signal termination.
Diode Networks			D Series		Low profile diode network conformal SIP	Signal clamping, input transient protections.

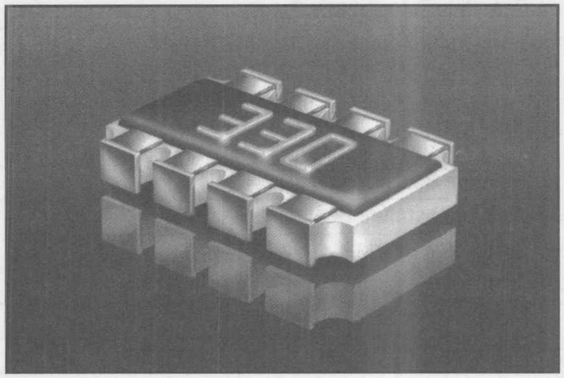
4

		SIP	DIP	SOMC	SOIC	SSOP	QSOP
Thick Film							
Pin Count	4	●					
	5	●					
	6	●					
	7	●					
	8	●					
	9	●					
	10	●					
	11	●					
	12	●					
	13	●					
	14	●	●	●	●		
	16		●	●	●		
	18		●				
	20		●				
	22						
	34						
Thin Film							
Pin Count	3	●					
	4	●					
	6	●					
	8	●	●		●		
	10	●					
	14	●	●		●		
	16		●		●		●
	18		●				
	20		●		●	●	●
	22		●				
	24		●		●	●	●
	28					●	●
	36					●	

MODEL SERIES BCN

Thick Film Network Chip Arrays

Distributor Item



MODEL STYLES

Model BCN 2D (1.6mm Width)	2 Resistors
Model BCN 4D (3.1mm Width)	4 Resistors
Model BCN 16 4A (1.6mm Width)	4 Resistors
Model BCN 31 8R & 8S (3.1mm Width)	8 Resistors

FEATURES

- Reliable monolithic construction
- Nickel barrier terminations
- Top side marking for easy identification
- Concave or convex termination styles
- Square or scalloped edges available

APPLICATIONS

- Pull up/pull down resistors for digital IC's
- Series termination on high speed data busses
- Current limit for LED displays

BENEFITS

- Saves board space over equivalent rated chip resistors
- Eliminates up to seven pick & place operations
- Single component reliability
- Leadless chip, reduced inductance
- Mounts close to active devices

ELECTRICAL

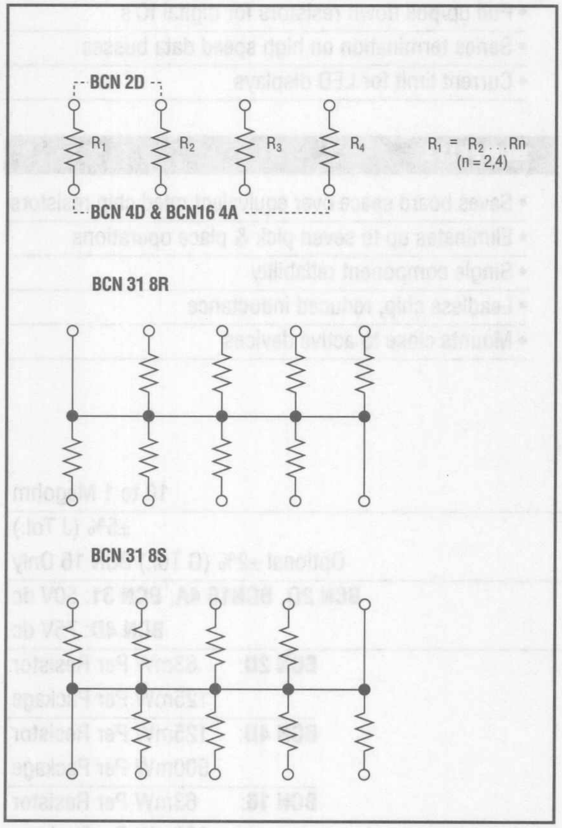
Standard Resistance Range, Ohms	10 to 1 Megohm
Standard Resistance Tolerance	±5% (J Tol.) Optional ±2% (G Tol.) BCN 16 Only
Operating Voltage, Maximum	**BCN 2D, BCN16 4A, BCN 31**: 50V dc **BCN 4D**: 75V dc
Power Rating, Watts at 70°C	**BCN 2D**: 63mW Per Resistor 125mW Per Package **BCN 4D**: 125mW Per Resistor 500mW Per Package **BCN 16**: 63mW Per Resistor 250mW Per Package **BCN 31**: 63mW Per Resistor 500mW Per Package

Specifications subject to change without notice.

ENVIRONMENTAL

Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	BCN 2D: ±300ppm/°C
	BCN 4D: ±200ppm/°C
	BCN 16: ±250ppm/°C
	BCN 31: ±200ppm/°C
Moisture Resistance	1,000 hours at +40°C, 95%R.H.(3.0%+0.1Ω ΔR)
High Temperature Operation	1,000 hours at 70°C (5.0%+0.1Ω ΔR)
Short Time Overload	2.5 x rated voltage, 5 sec. (2.0%+0.1Ω ΔR)
Temperature Cycling	-55°C to +125°C, 5 cycles (1.0%+0.1Ω ΔR)
Resistance to Solder Heat	260°C for 10 sec. (1.0%+0.1Ω ΔR)
Load Life	1,000 hours at 70°C (3.0%±0.1Ω ΔR)

SCHEMATICS



STANDARD RESISTANCE VALUES, OHMS

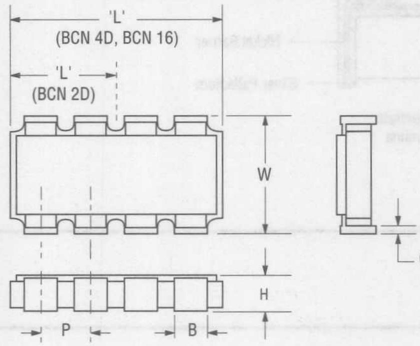
Model BCN 2D, BCN 4D & BCN 16

10	100	1K	10K	100K	1Meg
12	120	1.2K	12K	120K	
15	150	1.5K	15K	150K	
18	180	1.8K	18K	180K	
22	220	2.2K	22K	220K	
27	270	2.7K	27K	270K	
33	330	3.3K	33K	330K	
39	390	3.9K	39K	390K	
47	470	4.7K	47K	470K	
56	560	5.6K	56K	560K	
68	680	6.8K	68K	680K	
82	820	8.2K	82K	820K	

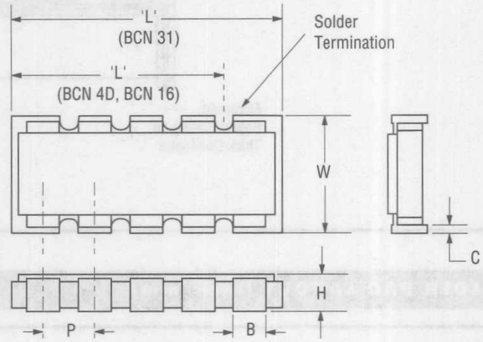
Model BCN 31 8R		Model BCN 31 8S	
47	10K	51	47K
220	47K	220	1Meg
330		1K	

Exterior Termination (Convex)

Scalloped Edge: Models BCN 2D, BCN 4D, BCN 16



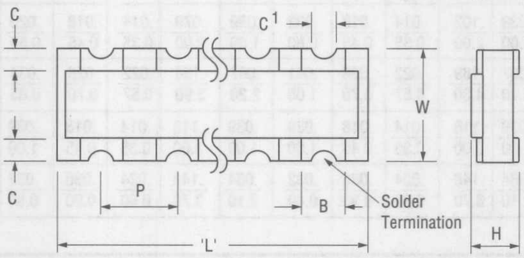
Square Edge: Models BCN 4D, BCN 16, BCN 31

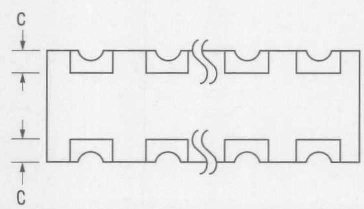


Inch / mm	L	W	H	P	B	C
BCN 2D	.063±.006 / 1.60±0.15	.063±.006 / 1.60±0.15	.020±.004 / 0.50±0.15	.031±.004 / 0.80±0.10	.020±.004 / 0.50±0.10	.010±.004 / 0.25±0.10
BCN 4D	.210±.008 / 5.10±0.20	.122±.008 / 3.10±0.20	.022±.004 / 0.55±0.10	.050±.008 / 1.27±0.20	.030±.008 / 0.80±0.20	.012±.008 / 0.30±0.20
BCN 16	.126±.004 / 3.2±0.10	.063±.004 / 1.60±0.10	.020±.004 / 0.50±0.10	.031±.002 / 0.80±0.05	.020±.004 / 0.50±0.10	.009±.005 / 0.225±0.125
BCN 31	.252±.004 / 6.40±0.10	.122±.004 / 3.10±0.10	.022±.004 / 0.50±0.30	.050±.002 / 1.27±0.20	.032±.004 / .080±0.20	.012±.004 / 0.30±0.10

Interior Termination (Concave)

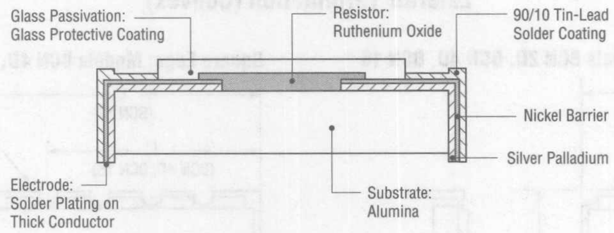
Square Edge: Models BCN 16, BCN 31



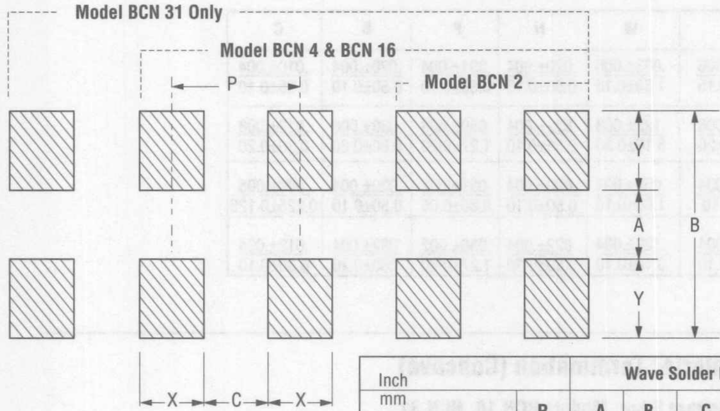


Inch / mm	L	W	H	P	B	C	C1
BCN 16	.126±.008 / 3.20±0.20	.063±.006 / 1.60±0.15	.024±.004 / 0.60±.10	.031±.004 / 0.08±0.10	.016±.006 / 0.40±0.15	.012±.008 / 0.30±0.20	.012±.008 / .03±.20
BCN 31	.252±.008 / 6.40±0.20	.122±.008 / 3.10±0.20	.022±.004 / 0.60±.1	.050 / 1.27	.039±.008 / 1.00±0.20	.024±.008 / 0.60±0.20	.020 / 0.50

CONSTRUCTION



SOLDER PAD LAYOUT (Inch/mm)



Inch / mm	Wave Solder Process P	A	B	C	X	Y	Re-Flow Solder Process A	B	C	X	Y
BCN 2D	.032 / 0.80	.039 / 1.00	.102 / 2.60	.014 / 0.35	.018 / 0.45	.032 / 0.80	.039 / 1.00	.079 / 2.00	.014 / 0.35	.018 / 0.45	.020 / 0.50
BCN 4D	.050 / 1.27	.087 / 2.20	.169 / 4.30	.022 / 0.57	.028 / 0.70	.041 / 1.05	.087 / 2.20	.154 / 3.90	.022 / 0.57	.028 / 0.70	.034 / 0.85
BCN16 4A	.032 / 0.80	.039 / 1.00	.118 / 3.00	.014 / 0.35	.018 / 0.45	.039 / 1.00	.039 / 1.00	.118 / 3.00	.014 / 0.35	.018 / 0.45	.039 / 1.00
BCN 31 8R & 8S	.050 / 1.27	.084 / 2.10	.148 / 3.70	.024 / 0.60	.036 / 0.90	.032 / 0.80	.084 / 2.10	.148 / 3.70	.024 / 0.60	.036 / 0.90	.032 / 0.80

ORDERING INFORMATION

BCN 4 D B 102 J 7

Model Series — BCN

No. of Resistors: — 4
BCN 2D = 2 Resistors
BCN 4D = 4 Resistors

Circuit Configuration: — D
D = Isolated

Edge Option (B = Square Edge): — B
BCN 2D: Scalloped Edge **Only**- No Code Used
BCN 4D: Scalloped Edge - No Code Used
Square Edge - Use Code 'B'

Resistance Code — 102

Tolerance — J

Packaging Option: — 7
7 = 7" Diameter Reel
BCN 2D = Paper Tape, 5K/Reel
BCN 4D = Embossed Tape, 4K/Reel
13 = 13" Diameter Reel
BCN 2D = Paper Tape, 20K/Reel
BCN 4D = Embossed Tape, 16K/Reel

BCN 16 4 A B I 102 J 7

Model Series — BCN

Width: — 16
16 = 1.6mm
31 = 3.1mm

No. of Resistors: — 4
BCN 16 4A = 4 Resistors
BCN 31 8R or 8S = 8 Resistors

Circuit Configuration: — A
A = Isolated (BCN16)
R = Bussed (reversed) (BCN 31)
S = Bussed (standard) (BCN 31)

Edge Option (B= Square Edge): — B
BCN 16: Scalloped Edge - No Code Used
Square Edge - Use Code 'B'
BCN 31: Square Edge **Only** - Use Code 'B'

Termination Code: — I
No code used for standard exterior termination
I = Interior (Concave) Termination
All interior termination requires 'B' for square edge

Resistance Code — 102

Tolerance — J

Packaging Option: — 7
7 = 7" Diameter Reel
BCN 16 = Paper Tape, 5K/Reel
BCN 31 = Embossed Tape, 4K/Reel
13 = 13" Diameter Reel
BCN 16 = Paper Tape, 20K/Reel
BCN 31 = Embossed Tape, 16K/Reel

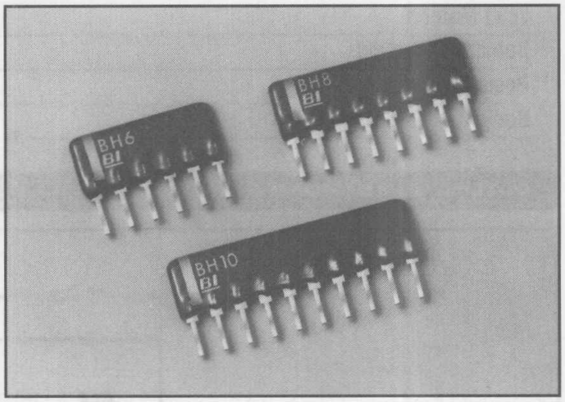
MODEL BH SERIES

Single In-Line

High Profile

Conformal Coated

Thick Film Resistor Network



ELECTRICAL

Standard Resistance Range, Ohms	22 to 1Meg
Standard Resistance Tolerance, at 25°C	±2%
Operating Temperature Range	-55°C to +155°C
Temperature Coefficient of Resistance	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Temperature Coefficient of Resistance, Tracking	±50ppm/°C
Maximum Operating Voltage	150V dc or √PR
Insulation Resistance	≥10,000 Megohms

ENVIRONMENTAL

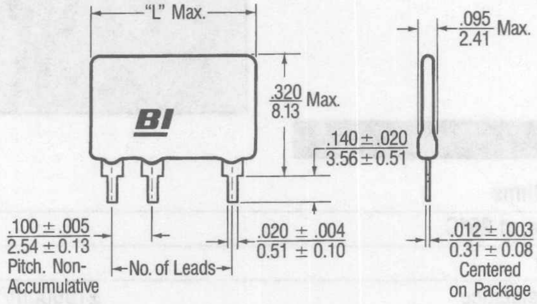
Thermal Shock plus Power Conditioning	ΔR 0.50%
Short Time Overload	ΔR 0.50%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 1,000 Hours	ΔR 2.00%
Resistance to Solder Heat (Per MIL-STD-202, Method 210, Cond.B)	ΔR 0.25%
Dielectric Withstanding Voltage	200V for 1 minute
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +155°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Copper Alloy, 90/10 Tin-Lead Plating
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Conformal Epoxy Resin

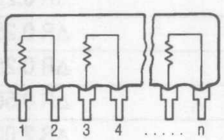
OUTLINE DIMENSIONS (Inch/mm)



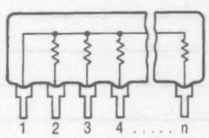
# of Leads		4	5	6	7	8	9	10	11	12	13	14
"L"	in.	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40
Max.	mm	10.16	12.70	15.24	17.78	20.32	22.86	25.40	27.94	30.48	33.02	35.56

SCHEMATICS

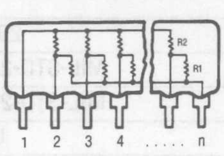
– 3 Circuit, Isolated Resistors



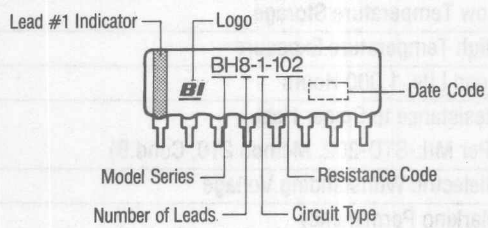
– 1 Circuit, Bussed Resistors



– 5 Circuit, Dual Terminator



TYPICAL PART MARKING



STANDARD RESISTANCE VALUES, OHMS

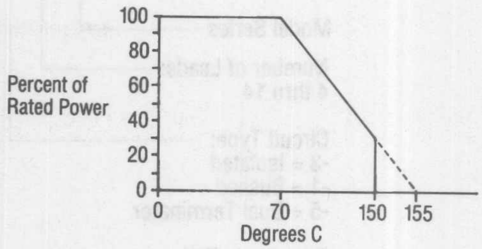
-3 Circuit (Isolated Resistors) and -1 Circuits (Bussed Circuits)

Ohms	Code	Ohms	Code	Ohms	Code
22	220	820	821	33K	333
27	270	1K	102	39K	393
33	330	1.2K	122	47K	473
39	390	1.5K	152	51K	513
47	470	1.8K	182	56K	563
51	510	2K	202	68K	683
56	560	2.2K	222	82K	823
68	680	2.7K	272	100K	104
82	820	3.3K	332	120K	124
100	101	3.9K	392	159K	154
120	121	4.7K	472	180K	184
150	151	5.1K	512	200K	204
180	181	5.6K	562	220K	224
200	201	6.8K	682	270K	274
220	221	8.2K	822	330K	334
270	271	10K	103	390K	394
330	331	12K	123	470K	474
390	391	15K	153	510K	514
470	471	18K	183	560K	564
510	511	20K	203	680K	684
560	561	22K	223	820K	824
680	681	27K	273	1Meg	105

-5 Circuit (Dual Terminators)

Ohms	Code	Ohms	Code	Ohms	Code
R1/R2	R1/R2	R1/R2	R1/R2	R1/R2	R1/R2
180/390	181/391	330/390	331/391	3K/6.2K	302/622
220/270	221/271	330/470	331/471		
220/330	221/331	330/680	331/681		

POWER DERATING CURVE



POWER DISSIPATION, WATTS AT 70°C

Model	Package	Per Resistor -1	Per Resistor -3	Per Resistor -5
BH6	1.25	.250	.400	.250
BH8	1.75	.250	.400	.250
BH10	2.25	.250	.400	.250

PACKAGING

Standard: Bulk

Capacity = 200 Units

4

ORDERING INFORMATION

BH 8 5 331 / 471 F

Model Series

Number of Leads:
4 thru 14

Circuit Type:
-3 = Isolated
-1 = Bussed
-5 = Dual Terminator

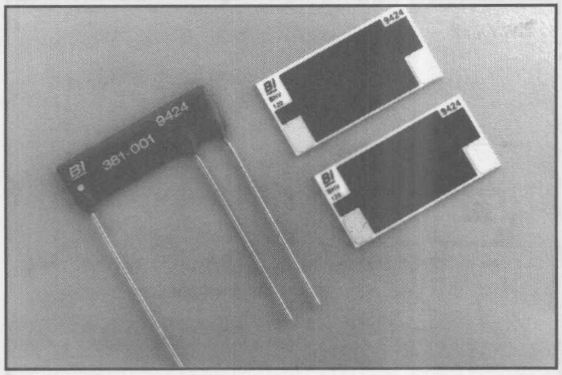
Resistance Code
First 2 digits are significant
(3 digits for ±1%)
Last digit denotes number
of trailing zeros

Tolerance Code:
(If other than standard)
F = ±1%
J = ±5%

R2 Resistance Code
(Add for -5 circuit only)

MODEL BHV SERIES

High Voltage / High Value
Conformal Coated
Thick Film Resistor Network



For leaded device consult factory

APPLICATIONS

- Photomultiplier power supplies
- Voltage sense in high voltage power supplies
- High voltage bleeder resistors
- Deflection circuitry in display systems and monitors

ELECTRICAL

Resistance Range, Maximum	1G Ohm
Standard Tolerances	±10%, ±5%
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance, Maximum	±150ppm/°C
Voltage Coefficient	<2ppm/V
Divider Ratio	1,000:1 Max.

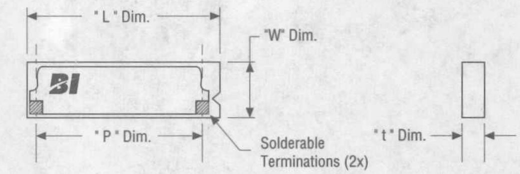
ENVIRONMENTAL (PER MIL-R-83401, REV. D)

Thermal Shock	ΔR 0.50%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.25%
Load Life, 1,000 Hours	ΔR 1.00%
Resistance to Solder Heat	ΔR 0.25%
Dielectric Withstanding Voltage, Minimum	5,000 Vdc
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL 94V-0 Rated
Storage	-55°C to +125°C

Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)

BHV XX RS

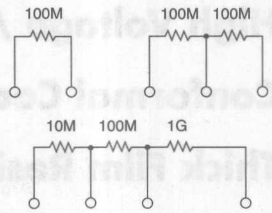


Inch/mm

TYPE	L	W	P	t
BHV 14 RS	1.00 / 25.4	0.25 / 6.35	0.87 / 22.0	0.03 / 0.75
BHV 17 RS	1.33 / 33.9	0.33 / 8.5	1.18 / 30.0	0.03 / 0.75
BHV 20 RS	1.00 / 25.4	0.50 / 12.7	0.87 / 22.0	0.03 / 0.75
BHV 30 RS	2.00 / 50.8	0.50 / 12.7	1.70 / 43.0	0.03 / 0.75

SCHEMATICS

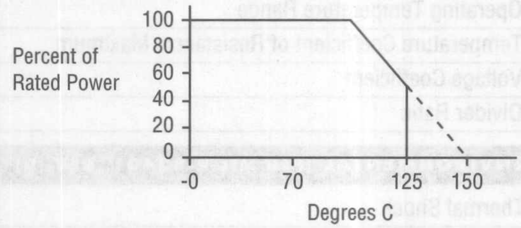
Samples here represent typical schematics. **Contact factory about your specific requirements.**



POWER (WATTS) DISSIPATION AT 70°C

Model	Package
BHV 14	0.8
BHV 17	0.9
BHV 20	2.0
BHV 30	3.0

POWER DERATING CURVE



CUSTOM CAPABILITIES

Consult factory for leaded devices, single-in-line and application specific voltage dividers.

STANDARD TYPES

BHV 14	14 kV, Max.
BHV 17	17 kV, Max.
BHV 20	20 kV, Max.
BHV 30	30 kV, Max.

MECHANICAL

Cover Coat	Polymer
Substrate Material	Alumina
Resistor Material	Cermet

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed Film, General Specifications

MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

4

ORDERING INFORMATION

BHV 10 RS XXX J

- BHV — Model Series
- 10 — Voltage Rating in kV
- RS = Polymer coated substrate with solder pads
- XXX — Resistance Code: First 2 digits are significant. Last digit denotes number of trailing zeros.
- J — Tolerance: J = ±5%, K = ±10%

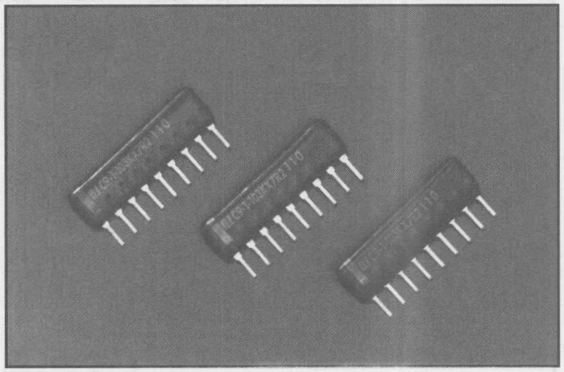
PACKAGING

Standard: 100 units per box

Option: Consult factory for special packaging to meet customer requirements

MODEL C-SERIES

Conformal Coated Single In-Line Capacitor Network



FEATURES

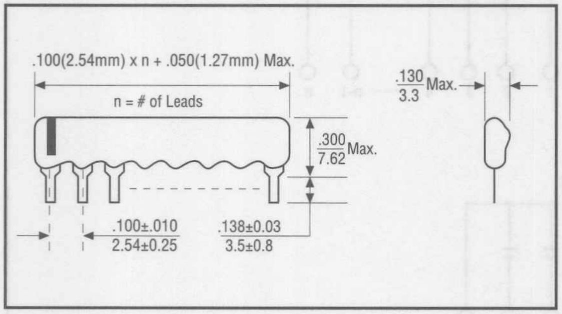
- Isolated or bussed circuits
- 4 to 14 pins

4

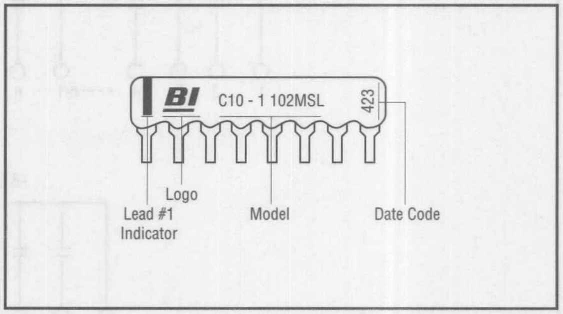
ELECTRICAL

Rated Voltage	25Vdc, 50Vdc, 100Vdc
Capacitance Range	10 to 470,000pF (Custom 2.2 to 10 pF max.)
Tolerance	J = ±5%
	K = ±10%
	M = ±20%
	Z = +80 to -20%
Temperature Coefficient	CG (±30ppm/°C), SL (+350/-1,000ppm/°C)
% of Change	±15% (X7R), +22/-88% (Y5V)
Operating Temperature Range	CG, SL & X7R: -55°C to +125°C
	Y5V: -30°C to +85°C

OUTLINE DIMENSIONS (Inch/mm)



TYPICAL PART MARKING



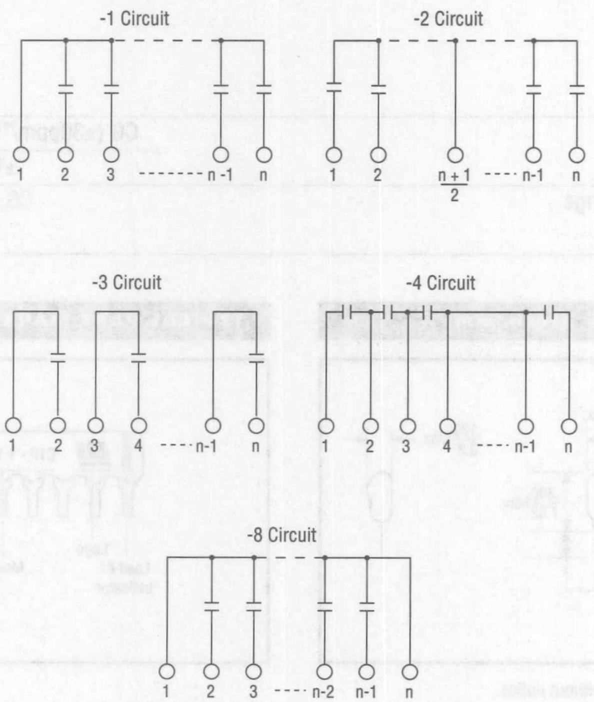
Specifications subject to change without notice.

ORDERING INFORMATION

C 10 1 102 M S 2

- Model Series — C
- No. of Leads: 4 to 14 pins — 10
- Circuit Type — 1
- Capacitance Code: 102 = 1,000pF — 102
- Tolerance: — M
  - J = ±5%
  - K = ±10%
  - M = ±20%
  - Z = −20% ~ +80%
- Dielectric: — S
  - S = SL:10pF ~ 3,300pF
  - X = X7R: 680pF ~ 47nF
  - Y = Y5V: 10pF ~ 1,500pF
  - N = NPO (CG): 10pF ~ 1,500pF
- Rated Voltage: — 2
  - 2 = 25V dc
  - 5 = 50V dc
  - 1 = 100V dc

SCHEMATICS

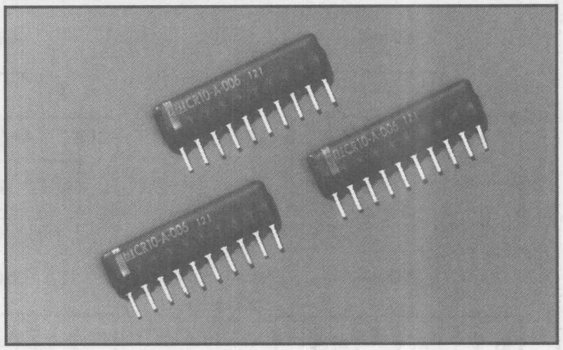


MODEL CR-SERIES

Conformal Coated

Single In-Line

Resistor/Capacitor Network



FEATURES

- 4 to 14 pin
- Standard and custom circuits
- Space saving design

ELECTRICAL (CAPACITOR)

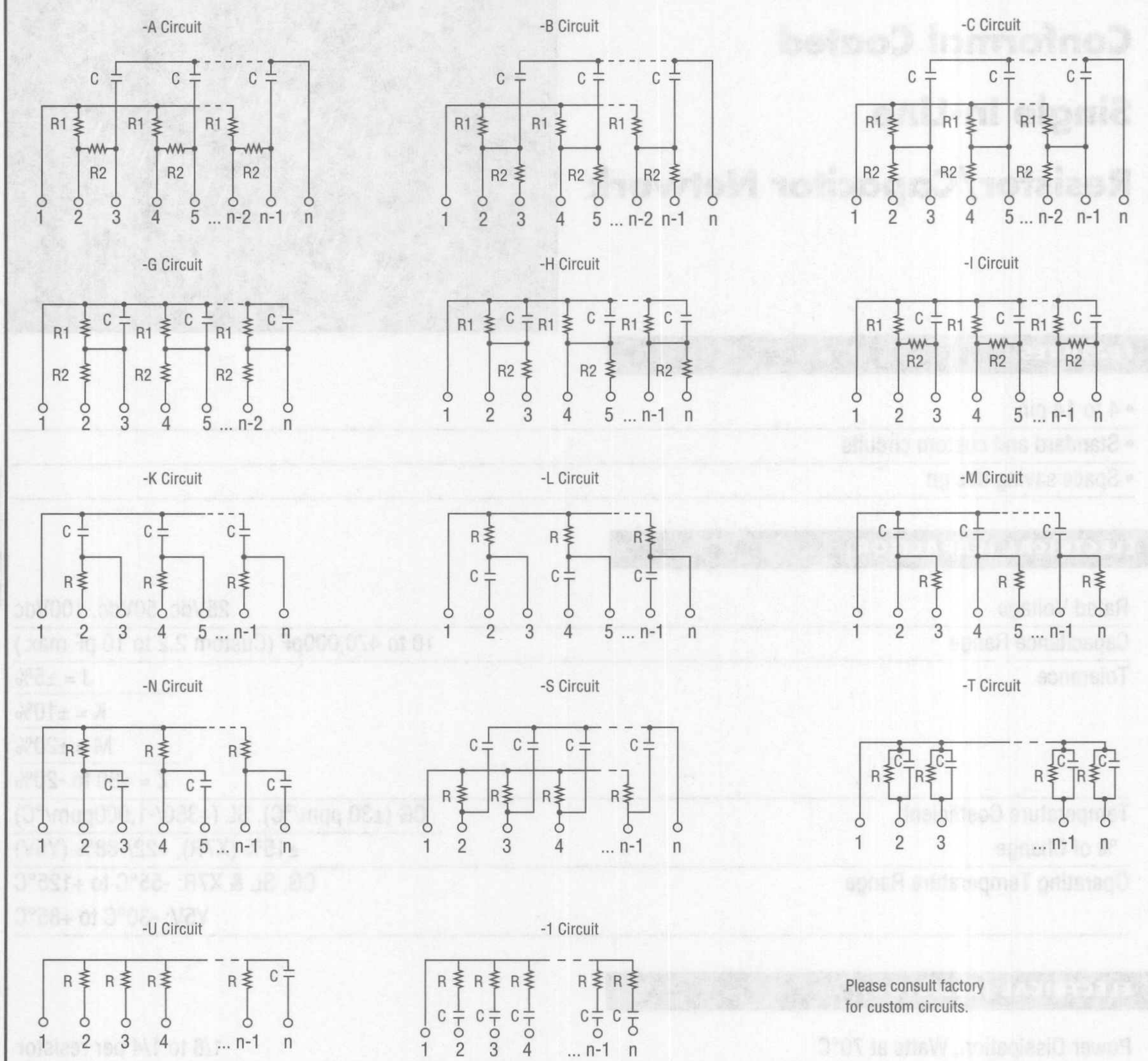
Rated Voltage	25Vdc, 50Vdc, 100Vdc
Capacitance Range	10 to 470,000pF (Custom 2.2 to 10 pF max.)
Tolerance	J = ±5%
	K = ±10%
	M = ±20%
	Z = +80 to -20%
Temperature Coefficient	CG (±30 ppm/°C), SL (+350/-1,000ppm/°C)
% of Change	±15% (X7R), +22/-88% (Y5V)
Operating Temperature Range	CG, SL & X7R: -55°C to +125°C
	Y5V: -30°C to +85°C

ELECTRICAL (RESISTOR)

Power Dissipation, Watts at 70°C	1/8 to 1/4 per resistor
Operating Voltage, Maximum	100Vdc
Standard Resistance Range, Ohms	10 to 2.2 Meg
Standard Resistance Tolerance	2%, 5%, 10%
Temperature Coefficient of Resistance	100 to 300ppm/°C
Operating Temperature Range	-55°C to +125°C

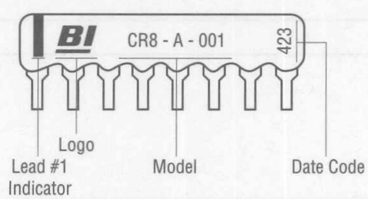
Specifications subject to change without notice.

SCHEMATICS

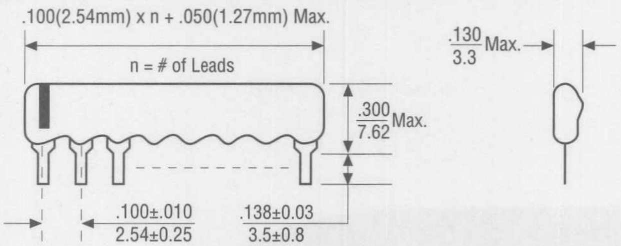


Please consult factory
for custom circuits.

TYPICAL PART MARKING



OUTLINE DIMENSIONS (Inch/mm)



ORDERING INFORMATION

Circuit 1

CR 9 1 101 J 101 K S 5

- **CR** – Model Series
- **9** – No. of Leads: 4 to 14 pins
- **1** – Circuit Type
- **101** – Resistance Code: 101 = 100Ω
- **J** – Resistance Tolerance and TCR:
  - G = ±2%, TCR = ±100ppm/°C
  - J = ±5%, TCR = ±200ppm/°C
  - K = ±10%, TCR = ±200ppm/°C
- **101** – Capacitance Code: 101 = 100pF
- **K** – Cap. Tolerance:
  - J = ±5%
  - K = ±10%
  - M = ±20%
  - Z = -20% to +80%
- **S** – Dielectric:
  - S = SL: 10pF ~ 3,300pF
  - X = X7R: 680pF ~ 47nF
  - Y = Y5V: 10pF ~ 1,500pF
  - N = NPO (CG): 10pF ~ 1,500pF
- **5** – Rated Voltage:
  - 2 = 25V dc
  - 5 = 50V dc
  - 1 = 100V dc

Custom Circuits A to U

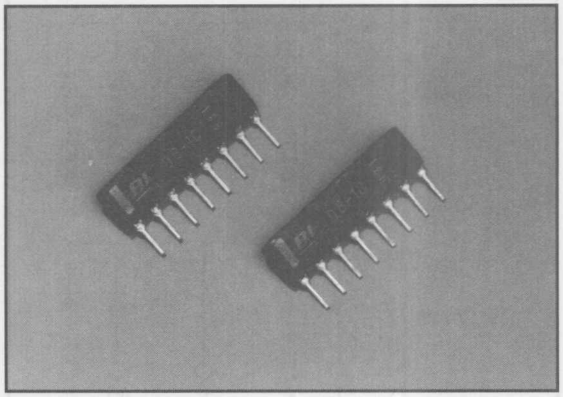
CR 10 A 001

- **CR** – Model Series
- **10** – No. of Leads: 4 to 14
- **A** – Circuit Type
- **001** – Unique Part Number (Assigned by Factory)

4

MODEL D-SERIES

Single In-Line
Conformal Coated
Diode Network



4

FEATURES

- 4 to 14 pins
- Multiple Circuit Configurations
- Space saving design

ELECTRICAL

Reverse Voltage, V_R	80V
Reverse Current, I_R	1.0μA (V_R=70V)
Forward Current, I_F	100mA average 300mA Surge (1μs Max.)
Forward Voltage, V_F	1.5V @ I_F=100mA
Package Power, P_{PKG}	200mW @ 25°C
Reverse Recovery Time, t_{rr}	4ns (V_R=6V, I_F=5mA, R_L=50Ω)
Capacitance, C	5.5pF (V_R=6V, f=1MHz)
Junction Temperature, T_J, Max.	125°C
Storage Temperature	-55°C to +125°C

ORDERING INFORMATION

D 9 1 A

Model Series — D

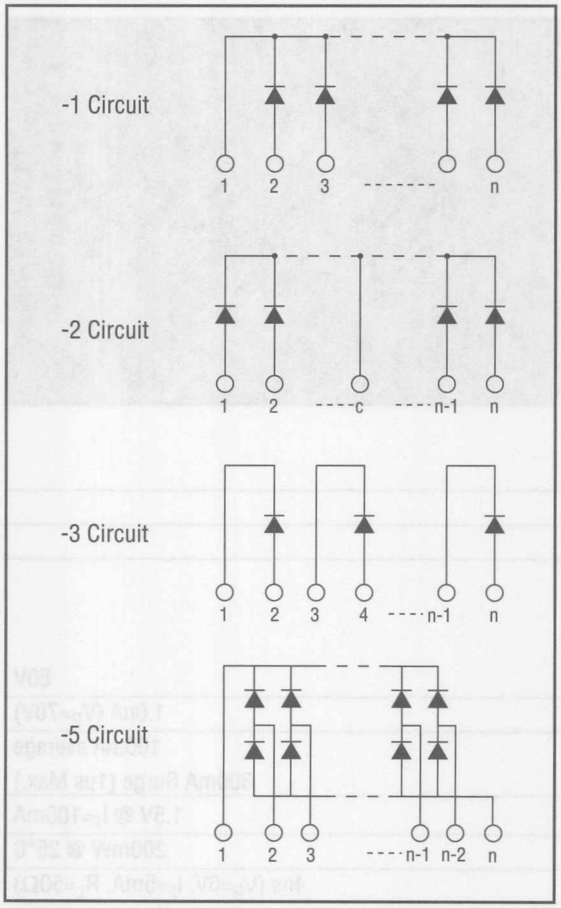
No. of Leads: 4 to 14 — 9

Schematic — 1

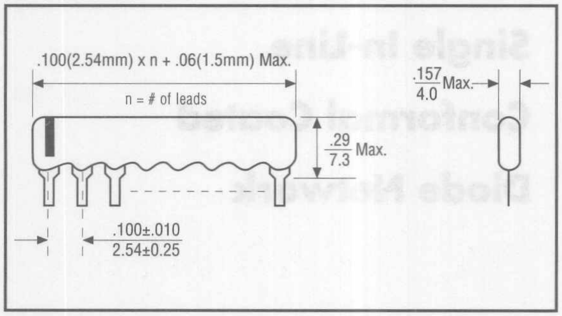
Circuit Code: — A
A: Common Anode
C: Common Cathode

Specifications subject to change without notice.

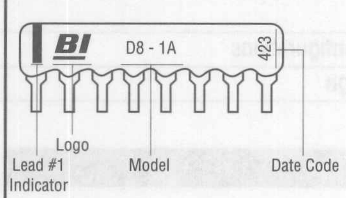
SCHEMATICS (COMMON CATHODE TYPE)



OUTLINE DIMENSIONS (Inch/mm)



TYPICAL PART MARKING



Marking Color:
1 A (Common Anode-Type)
White Color

2 C (Common Cathode Type)
Yellow Color

MODEL L-SERIES

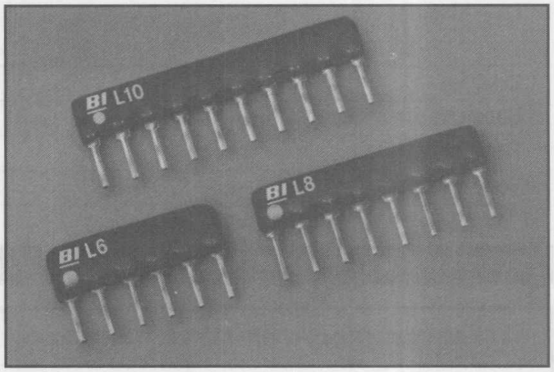
Single In-Line

Low Profile

Conformal Coated

Thick Film Resistor Network

Distributor Item



4

ELECTRICAL

Standard Resistance Range, Ohms	22 to 1Meg
Standard Resistance Tolerance, at 25°C	±2%
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Temperature Coefficient of Resistance, Tracking	±50ppm/°C
Maximum Operating Voltage	100V dc or √PR
Insulation Resistance	≥10,000 Megohms

ENVIRONMENTAL

Thermal Shock plus Power Conditioning	ΔR 0.70%
Short Time Overload	ΔR 0.25%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 1,000 Hours	ΔR 2.00%
Resistance to Solder Heat (Per MIL-STD-202, Method 210, Cond.B)	ΔR 0.25%
Dielectric Withstanding Voltage	200V for 1 minute
Marking Permanency	MIL-STD 202, Method 215
Lead Solderability	MIL-STD 202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Steel Alloy (Standardl) Copper Alloy (Option)
Lead Finish	90/10 Tin-Lead
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Conformal Epoxy Resin

STANDARD RESISTANCE VALUES, OHMS

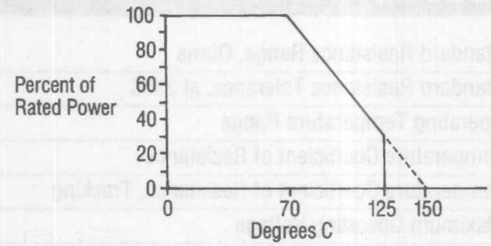
-3 Circuit (Isolated Resistors) and -1 Circuits (Bussed Circuits)

Ohms	Code	Ohms	Code	Ohms	Code
22	220	820	821	33K	333
27	270	1K	102	39K	393
33	330	1.2K	122	47K	473
39	390	1.5K	152	51K	513
47	470	1.8K	182	56K	563
51	510	2K	202	68K	683
56	560	2.2K	222	82K	823
68	680	2.7K	272	100K	104
82	820	3.3K	332	120K	124
100	101	3.9K	392	150K	154
120	121	4.7K	472	180K	184
150	151	5.1K	512	200K	204
180	181	5.6K	562	220K	224
200	201	6.8K	682	270K	274
220	221	8.2K	822	330K	334
270	271	10K	103	390K	394
330	331	12K	123	470K	474
390	391	15K	153	510K	514
470	471	18K	183	560K	564
510	511	20K	203	680K	684
560	561	22K	223	820K	824
680	681	27K	273	1Meg	105

-5 Circuit (Dual Terminators)

Ohms	Code	Ohms	Code	Ohms	Code
R1/R2	R1/R2	R1/R2	R1/R2	R1/R2	R1/R2
180/390	181/391	330/390	331/391	3K/6.2K	302/622
220/270	221/271	330/470	331/471		
220/330	221/331	330/680	331/681		

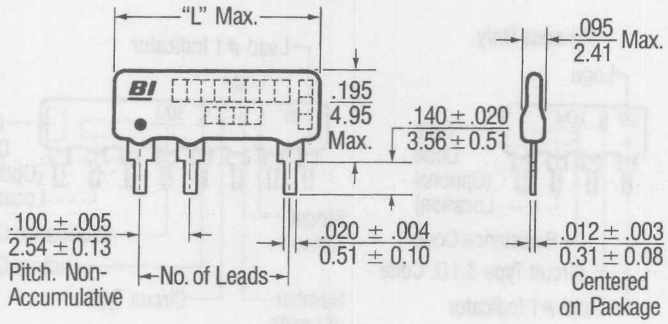
POWER DERATING CURVE



POWER DISSIPATION, WATTS AT 70°C

Model	Package	— Resistor (Per Circuit) — -1	-3	-5
L06	.6	.125	.200	.125
L08	.8	.125	.200	.125
L10	1.0	.125	.200	.125

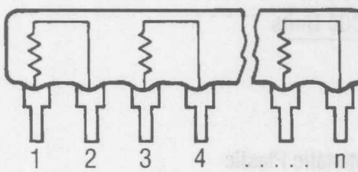
OUTLINE DIMENSIONS (Inch/mm)



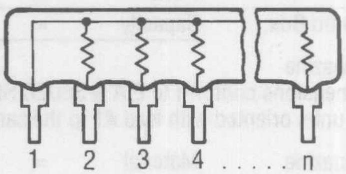
# of Leads		4	5	6	7	8	9	10	11	12	13	14
"L"	in.	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40
Max.	mm	10.16	12.70	15.24	17.78	20.32	22.86	25.40	27.94	30.48	33.02	35.56

SCHEMATICS

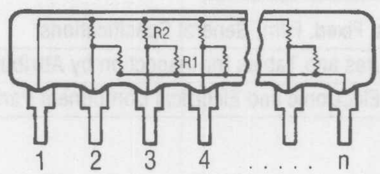
-3 Circuit, Isolated Resistors



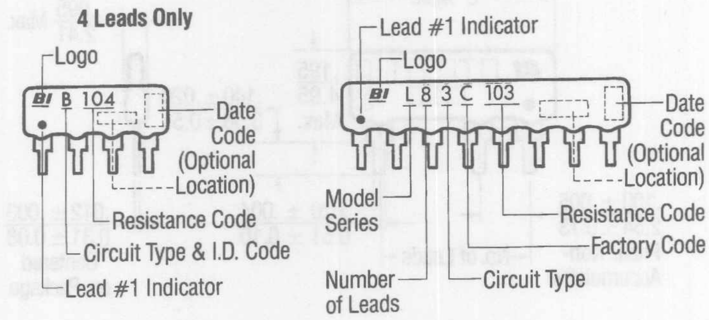
-1 Circuit, Bussed Resistors



-5 Circuit, Dual Terminator



TYPICAL PART MARKING



PACKAGING

Standard: Bulk

	Quantity	=	500 (Europe) 200 Units (USA/Aisa)

Option: Tape in Ammo Box (Steel pins only)
All units oriented with lead #1 to the left of direction of feed

Tape:	Width	=	18mm
	Pitch	=	12.7mm
Ammo Box:	Capacity	=	1,000 Units

Option: Magazine
Dimensions conform to EIA & JEDEC Standards
All units oriented with lead #1 to the same side

Magazine	Material	=	Antistatic Plastic

APPLICABLE DOCUMENTS

MIL-R-83401	—	Resistor Networks, Fixed, Film, General Specifications
MIL-STD-105	—	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202	—	Test Methods for Electronic and Electrical Component Parts

ORDERING INFORMATION

L 08 5 C 331 / 471 F XX

- **L** — Model Series
- **08** — Number of Leads
  4 thru 14
- **5** — Circuit Type
  -3 = Isolated
  -1 = Bussed
  -5 = Dual Terminator
- **C** — Lead Code
  S = Steel Pins
  C = Copper Pins
- **331** — Resistance Code
  First 2 digits are significant (3 digits for ±1%) Last digit denotes number of trailing zeros. For F Tolerance first 3 digits are significant. Fourth digit denotes number of trialing zeros.
- **471** — R2 Resistance Code
  (Add for -5 circuit only)
- **F** — Tolerance Code
  (No code used for 2% Std.)
  F = ±1%
  J = ±5%
- **XX** — Packaging Option
  AP = Ammo Pack
  M1 or M2 = Tube

Refer to Packaging for Automation Section (Page A-4) for M1 & M2 tube capacity and dimensions.

4

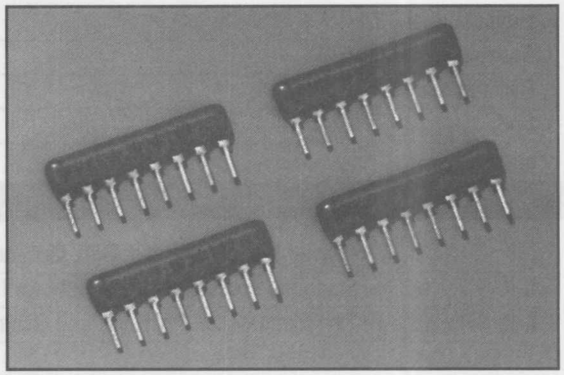
MODEL M-SERIES

Single In-Line

Low Profile

Conformal Coated

Thick Film Resistor Network



4

ELECTRICAL

Standard Resistance Range, Ohms	22 to 1Meg
Standard Resistance Tolerance, at 25°C	±2% (Optional: 1% & 5%)
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±200ppm/°C
Temperature Coefficient of Resistance Tracking	±50ppm/°C
Maximum Operating Voltage	100Vdc or √PR
Insulation Resistance, Minimum	10,000 Megohms

ENVIRONMENTAL

Thermal Shock plus Power Conditioning	ΔR 0.50%
Short Time Overload	ΔR 0.25%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration Shock	ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 1,000 Hours	ΔR 1.00%
Resistance to Solder Heat (Per MIL-STD-202, Method 210, Cond.B)	ΔR 0.25%
Dielectric Withstanding Voltage	100V for 1 minute
Marking Permanency	per MIL-STD-202, Method 215
Lead Solderability	per MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Solder Coated Steel Alloy
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Conformal Epoxy Resin

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes

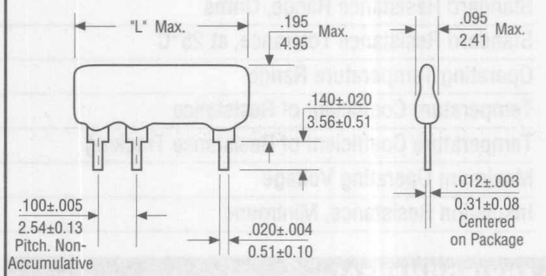
MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

STANDARD RESISTANCE VALUES, OHMS

-3 Circuit (Isolated Resistors) and -1 Circuits (Bussed Circuits)					
Ohms	Code	Ohms	Code	Ohms	Code
22	220	820	821	33K	333
27	270	1K	102	39K	393
33	330	1.2K	122	47K	473
39	390	1.5K	152	51K	513
47	470	1.8K	182	56K	563
51	510	2K	202	68K	683
56	560	2.2K	222	82K	823
68	680	2.7K	272	100K	104
82	820	3.3K	332	120K	124
100	101	3.9K	392	150K	154
120	121	4.7K	472	180K	184
150	151	5.1K	512	200K	204
180	181	5.6K	562	220K	224
200	201	6.8K	682	270K	274
220	221	8.2K	822	330K	334
270	271	10K	103	390K	394
330	331	12K	123	470K	474
390	391	15K	153	510K	514
470	471	18K	183	560K	564
510	511	20K	203	680K	684
560	561	22K	223	820K	824
680	681	27K	273	1Meg	105

-5 Circuit (Dual Terminators)					
Ohms	Code	Ohms	Code	Ohms	Code
R1/R2	R1/R2	R1/R2	R1/R2	R1/R2	R1/R2
180/390	181/391	330/390	331/391	3K/6.2K	302/622
220/270	221/271	330/470	331/471		
220/330	221/331	330/680	331/681		

OUTLINE DIMENSIONS (Inch/mm)

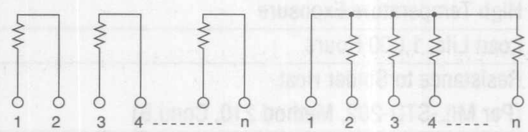


# of Leads		4	5	6	7	8	9	10	11	12	13	14
"L"	inch	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40
Max.	mm	10.16	12.70	15.24	17.78	20.32	22.86	25.40	27.94	30.48	33.02	35.56

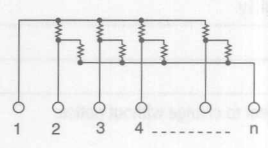
SCHEMATICS

-3 Circuit Isolated Resistors

-1 Circuit Bussed Resistors



-5 Circuit, Dual Terminator



ORDERING INFORMATION

M 8 5 331 / 471 J XX

- M — Model Series
- 8 — Number of Leads: 4 thru 14
- 5 — Circuit Type:
  - -3 = Isolated
  - -1 = Bussed
  - -5 = Dual Terminator
- 331 — Resistance Code: First 2 digits are significant (3 digits for ±1%). Last digit denotes number of trailing zeros
- 471 — R2 Resistance Code (Add for -5 circuit only)
- J — Tolerance Code:
  - F = ±1%
  - G = ±2% (standard)
  - J = ±5%
- XX — Packaging Option:
  - AP = Ammo Pack
  - M1 or M2 Tube*

*** Refer to Packaging for Automation Section (Page A-4) for M1 & M2 tube capacity and dimensions**

4

PACKAGING

Standard: Bulk

Quantity = 200 Units

Option: Tape in Ammo Box

All units oriented with lead #1 to the left of direction of feed

Tape:	Width	=	18mm
	Pitch	=	12.7mm
Ammo Box:	Capacity	=	1,000 Units

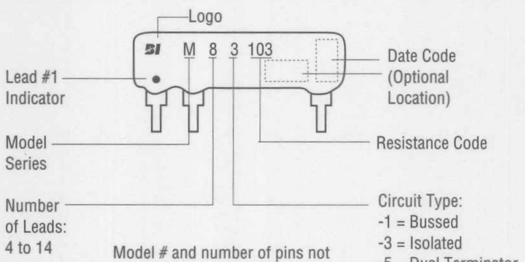
Option: Magazines

Dimensions conform to EIA & JEDEC Standards

All units oriented with lead #1 to the same side

Magazine: Material = Antistatic Plastic

TYPICAL PART MARKING



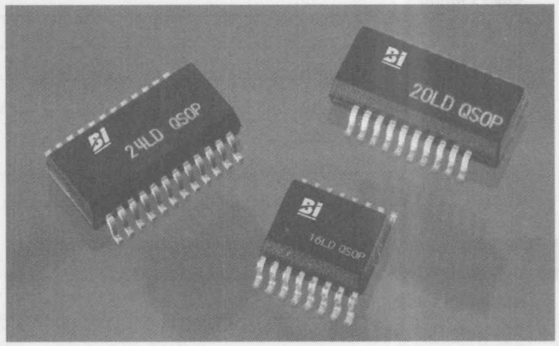
Model # and number of pins not marked on 4 and 5-pin packages

POWER DISSIPATION, WATTS AT 70°C

		Resistor (Per Circuit)		
Model	Package	-1	-3	-5
M06	.6	.125	.200	.125
M08	.8	.125	.200	.125
M10	1.0	.125	.200	.125

MODELS
NQS16, NQS20, NQS24
Surface Mount
.025" Pitch Dual In-Line
Precision Thin Film
Resistor Network

NEW PRODUCT



4

FEATURES/BENEFITS

- Up to 22 bussed elements in one package
- Nichrome element on ceramic substrate for reduced cross talk and high precision
- Industry standard QSOP package

ELECTRICAL

Operating Temperature Range	-55°C to +125°C
Resistance Voltco	≈0
Interlead Capacitance	<2pF
Operating Voltage, Maximum	100V dc or √PR
Insulation Resistance	≥10,000 Megohms
Noise, Maximum (MIL-STD-202, Method 308)	-40dB

ENVIRONMENTAL

Thermal Shock plus Power Conditioning	ΔR 0.25%
Low Temperature Operation	ΔR 0.10%
Short Time Overload	ΔR 0.10%
Terminal Strength	ΔR 0.10%
Moisture Resistance	ΔR 0.20%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.10%
High Temperature Storage	ΔR 0.10%
Load Life, 1,000 Hours	ΔR 0.10%
Resistance to Solder Heat	ΔR 0.10%
Dielectric Withstanding Voltage	100V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammabilty	UL-94V-0 Rated
Storage	-55°C to +125°C

Specifications subject to change without notice.

MECHANICAL

Lead Plating	85/15 Tin Lead
Lead Material	Copper Alloy
Lead Configuration	Gull Wing
Lead Coplanarity	0.004" (0.102mm)
Substrate Material	Alumina
Resistor Material	Nichrome
Body Material	Molded Epoxy

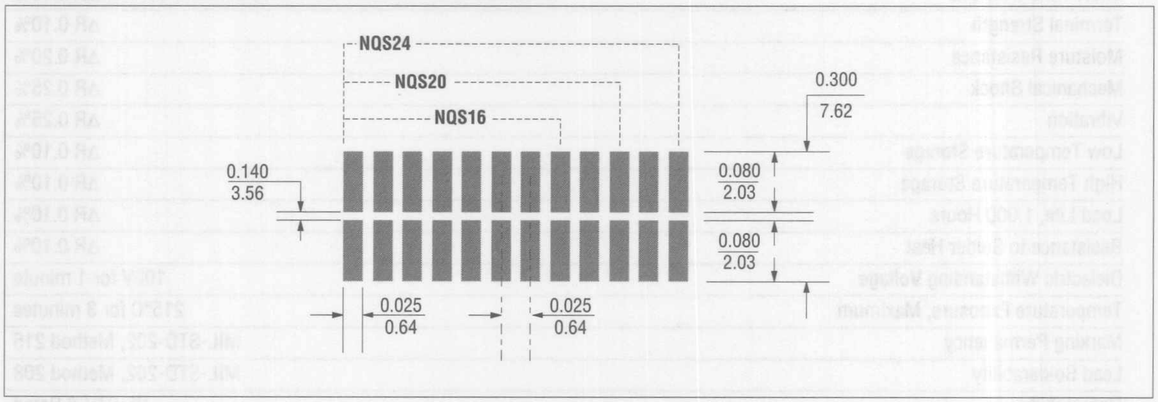
TOLERANCES

Accuracy Code	**B**	**D**	**F**
Absolute Resistance Tolerances, at 25°C	0.1%	0.5%	1.0%
Ratio	0.1%	0.1%	0.5%
Temperature Coefficient of Resistance		±25ppm/°C ±50ppm/°C ±100ppm/°C	
Temperature Coefficient of Resistance, Tracking		±5ppm/°C	

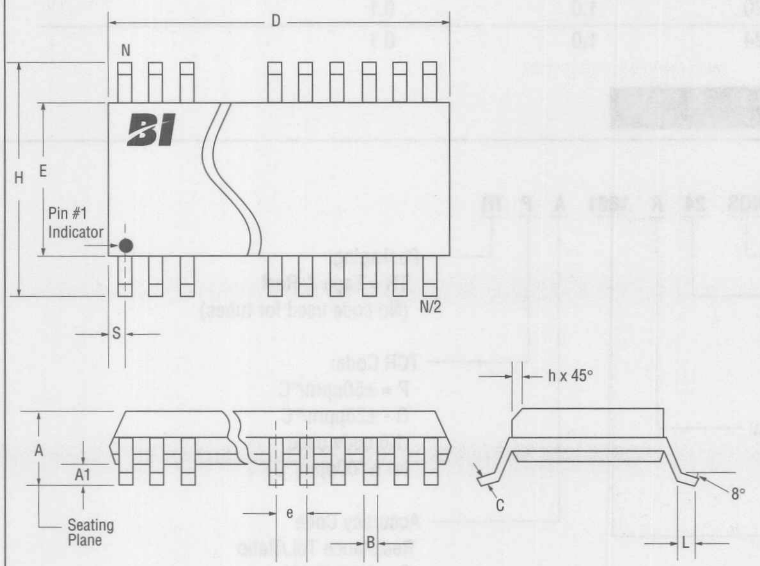
STANDARD RESISTANCE VALUES, OHMS

NQS16A		NQS20A		NQS20B		NQS24A	
Ohms	Code	Ohms	Code	Ohms	Code	Ohms	Code
1K	1001	3K	3001	10K	1002	3K	3001
10K	1002	267K	2673				
34K	3402						
47K	4702						
100K	1003						

RECOMMENDED SOLDER PAD LAYOUTS



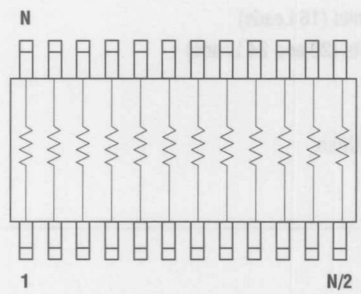
OUTLINE DIMENSIONS (Inch/mm)



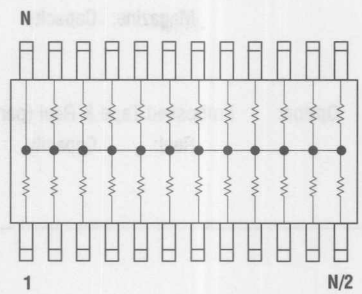
Model	NQS16	NQS20	NQS24
Dim. A (Max.)	0.068 / 1.727	0.068 / 1.727	0.068 / 1.727
Dim. A1 (Max.)	0.008 / 0.203	0.008 / 0.203	0.008 / 0.203
Dim. B (Max.)	0.012 / 0.305	0.012 / 0.305	0.012 / 0.305
Dim. C (Max.)	0.0098 / 0.249	0.0098 / 0.249	0.0098 / 0.249
Dim. D (Max.)	0.197 / 5.004	0.345 / 8.763	0.345 / 8.763
Dim. E (Max.)	0.157 / 3.988	0.157 / 3.988	0.157 / 3.988
Dim. e (Max.)	0.025 / 0.635	0.025 / 0.635	0.025 / 0.635
Dim. H (Max.)	0.244 / 6.198	0.244 / 6.198	0.244 / 6.198
Dim. h (Max.)	0.016 / 0.406	0.016 / 0.406	0.016 / 0.406
Dim. L (Max.)	0.035 / 0.889	0.035 / 0.889	0.035 / 0.889
Dim. S (Max.)	0.010 / 0.254	0.06 / 1.524	0.035 / 0.889

SCHEMATICS

NQS16A, NQS20A, NQS24A
Isolated Resistors



NQS16B, NQS20B, NQS24B
Bussed Resistors



NQS16: N = 16 Leads
NQS20: N = 20 Leads
NQS24: N = 24 Leads

POWER DISSIPATION, WATTS AT 70°C

Model	Package	Resistor
NQS16	0.8	0.1
NQS20	1.0	0.1
NQS24	1.0	0.1

ORDERING INFORMATION

NQS 24 A 1001 A P TR

Model Series — NQS

No. of Leads: — 24
- 16 = 16 Leads
- 20 = 20 Leads
- 24 = 24 Leads

Circuit Configuration: — A
- A = Isolated
- B = Bussed

Resistance Code: — 1001
First 3 digits are significant. Last digit denotes the number of trailing zeros.

Accuracy Code — A
Resistance Tol./Ratio
- B = 0.1%/0.1%
- D = 0.5%/0.1%
- F = 1.0%/0.5%

TCR Code: — P
- P = ±50ppm/°C
- Q - ±25ppm/°C
- (No code used for ±100ppm/°C)

Packaging: — TR
- TR = Tape & Reel
- (No code used for tubes)

PACKAGING

Standard: Magazine
All units oriented with lead #1 to the same side.

Magazine:	Capacity	=	100 Units (16 Leads)
			50 Units (20 and 24 Leads)

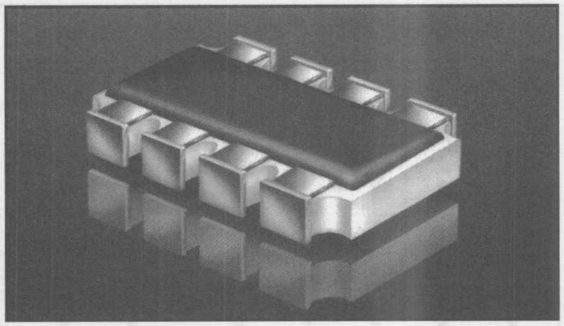
Option: Embossed Tape & Reel (per EIA 481)

Reel:	Capacity	=	1,500 Units

RC SERIES

Leadless Surface Mount
Chip Resistor
Capacitor Network

NEW PRODUCT



FEATURES

- Small outline
- Low profile suitable for PCMCIA
- Low inductance leadless design
- Available in three popular sizes: 0805, 1206, 2512
- Nickel barrier terminations

APPLICATIONS

- High speed AC line termination
- EMI/RFI filtering

4

ELECTRICAL

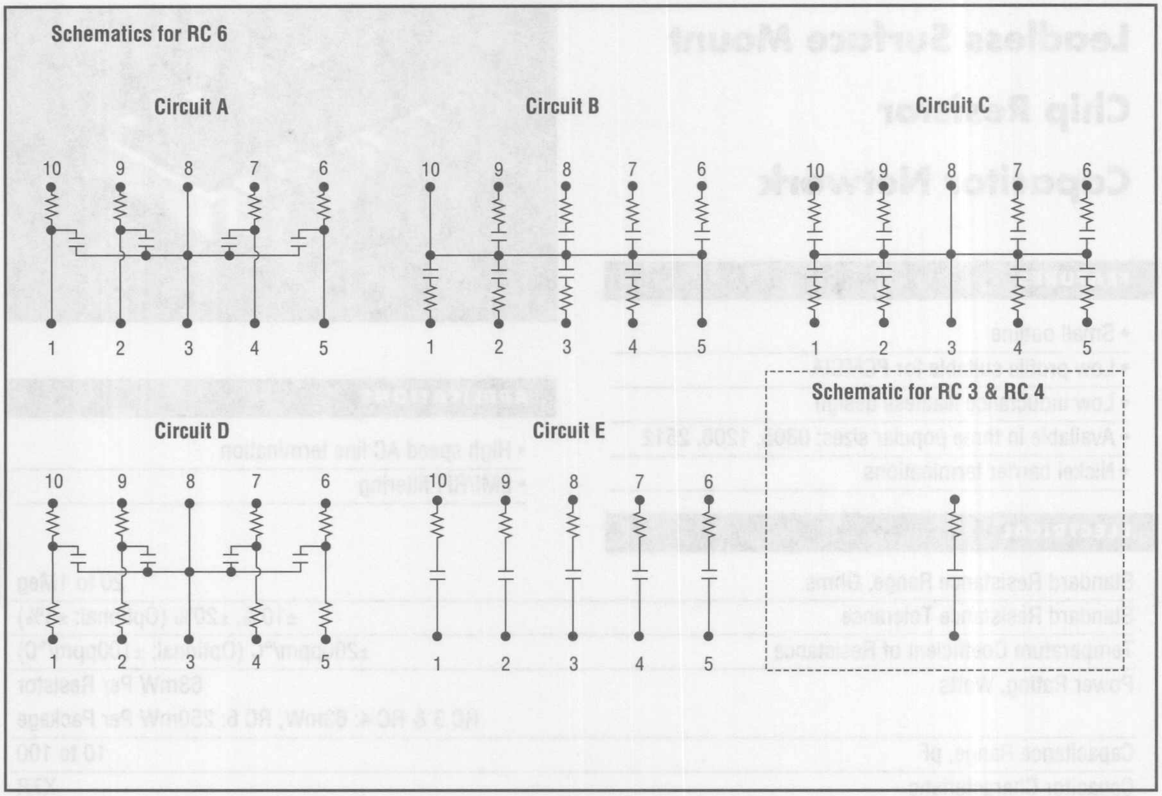
Standard Resistance Range, Ohms	20 to 1Meg
Standard Resistance Tolerance	±10%, ±20% (Optional: ±5%)
Temperature Coefficient of Resistance	±200ppm/°C (Optional: ±100ppm/°C)
Power Rating, Watts	63mW Per Resistor RC 3 & RC 4: 63mW, RC 6: 250mW Per Package
Capacitance Range, pF	10 to 100
Capacitor Characteristic	X7R
Capacitor Tolerance	±20% at 1kHz, 25°C
Capacitor Voltage Rating	25V dc
Capacitor Max. ΔC, -55°C to +125°C	±15%
Capacitor Dissipation Factor	2.5% Max.
Capacitor Dielectric Withstanding Voltage	125V dc, 5 sec. 50mA Charge
Capacitor Insulation Resistance	≥10,000 Megohms
Operating Temperature Range	-25°C to +85°C

ENVIRONMENTAL

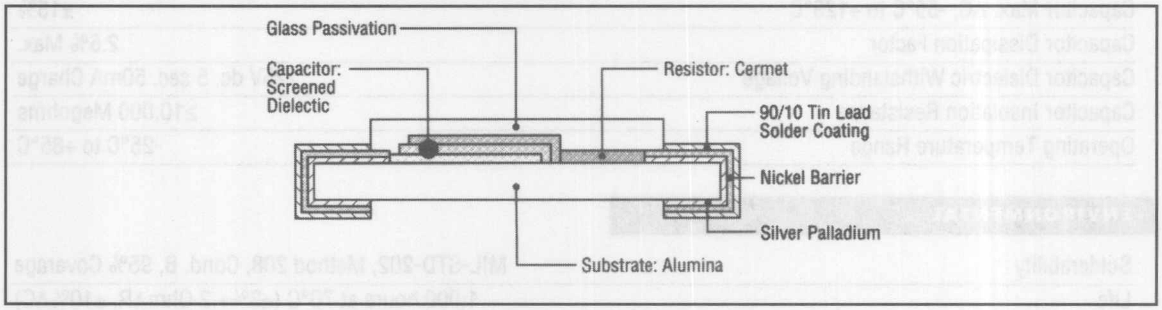
Solderability	MIL-STD-202, Method 208, Cond. B, 95% Coverage
Life	1,000 hours at 70°C (±3%+.2 OhmΔR, ±10%ΔC)
Thermal Shock	MIL-STD-202F, Method 107, Cond. A (±3%+.2 OhmΔR, ±10%ΔC)
Moisture Resistance	MIL-STD-202F, Method 106 (±3%+.2 OhmΔR, ±10%ΔC)

Specifications subject to change without notice.

SCHEMATICS

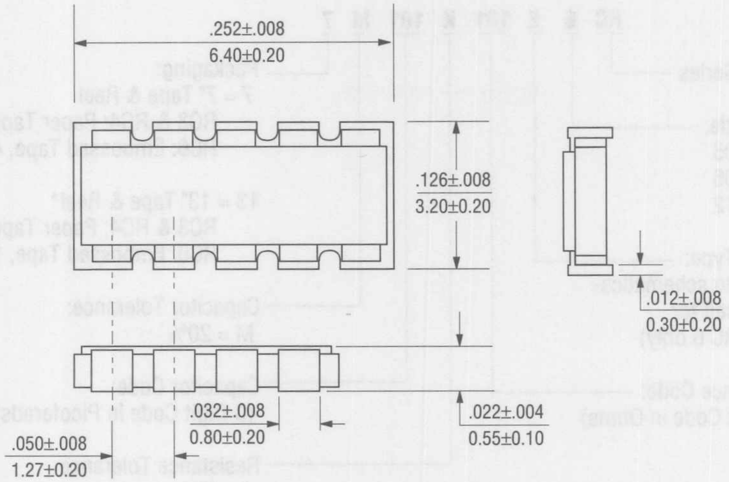


CONSTRUCTION



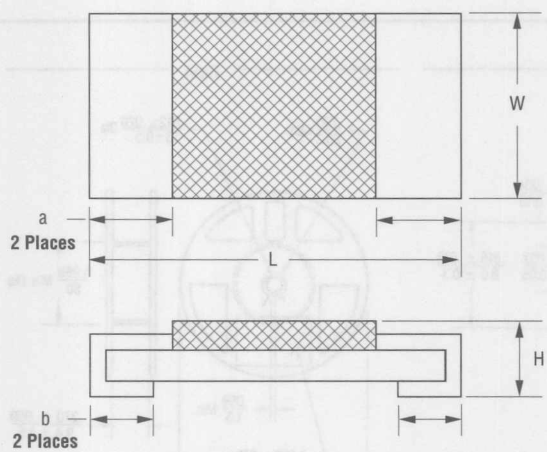
OUTLINE DIMENSIONS (Inch/mm)

Model RC 6



OUTLINE DIMENSIONS (Inch/mm)

Model RC 3 & RC 4



Model	L	W	H	a	b
RC 3	.079±.008 / 2.0±0.2	.049 $^{+.004}_{-.002}$ / 1.25 $^{+0.10}_{-0.05}$	.018±.004 / 0.45±0.1	.016±.008 / 0.4±0.2	.014±.006 / 0.35±0.15
RC 4	.122±.004 / 3.1±0.1	.061±.004 / 1.55±0.1	.022 $^{+.004}_{-.002}$ / 0.55 $^{+0.10}_{-0.05}$	.018±.008 / 0.45±0.1	.014±.006 / 0.35±0.15

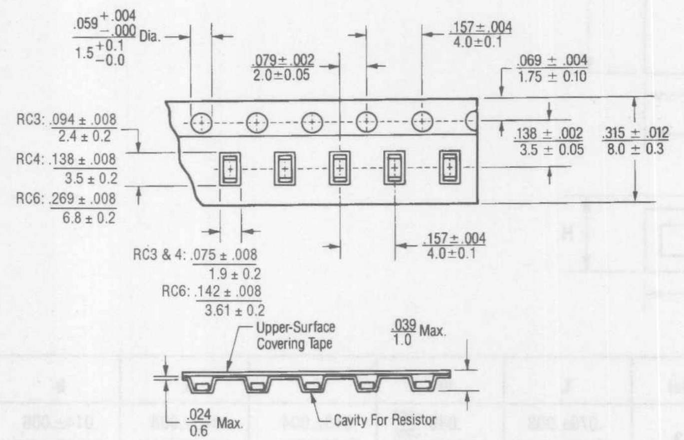
ORDERING INFORMATION

RC 6 E 101 K 101 M 7

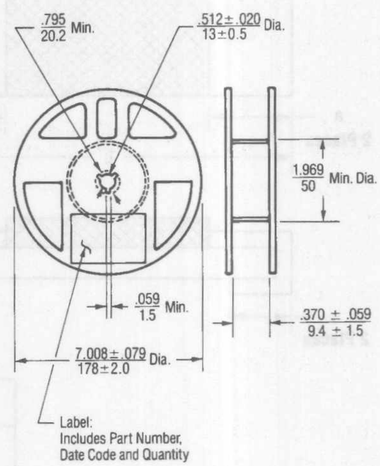
- Model Series — RC
- Size Code: — 6
  - 3 = 0805
  - 4 = 1206
  - 6 = 2512
- Circuit Type: (Refer to schematics-Code used for Model RC 6 only) — E
- Resistance Code: (3 Digit Code in Ohms) — 101
- Resistance Tolerance: — K
  - J = 5%
  - K = 10%
- Capacitor Code: (3 Digit Code in Picofarads) — 101
- Capacitor Tolerance: — M
  - M = 20%
- Packaging: — 7
  - 7 = 7" Tape & Reel
    - RC3 & RC4: Paper Tape, 5K/Reel
    - RC6: Embossed Tape, 4K/Reel
  - 13 = 13" Tape & Reel*
    - RC3 & RC4: Paper Tape, 20K/Reel
    - RC6: Embossed Tape, 16K/Reel

PACKAGING (Inch/mm)

Embossed Tape



Reel

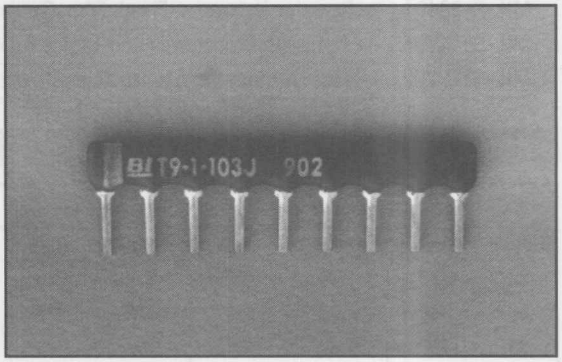


MODEL T SERIES

Super Low Profile

Single In-Line

Thick Film Resistor Network



ELECTRICAL

Standard Resistance Range, Ohms	22 to 1Meg
Standard Resistance Tolerance, at 25°C	J Tol: 5% (Optional G Tol: ±2%)
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±200ppm/°C
Temperature Coefficient of Resistance Tracking	±50ppm/°C
Maximum Operating Voltage	50V dc or √PR
Insulation Resistance	≥10,000 Megohms

4

MECHANICAL

Lead Material	Steel Alloy
Lead Finish	Solder (90/10 Typical)
Substrate Material	96% Alumina
Resistor Material	Cermet
Body Material	Conformal Epoxy Resin

ENVIRONMENTAL (PER MIL-R 83401, REV. D)

Thermal Shock	ΔR ±0.50%
Short Time Overload	ΔR ±0.50%
Terminal Strength	ΔR ±0.25%
Moisture Resistance	ΔR ±0.50%
Mechanical Shock	ΔR ±0.25%
Vibration Shock	ΔR ±0.25%
Low Temperature Storage	ΔR ±0.25%
High Temperature Exposure	ΔR ±0.50%
Load Life, 1,000 Hours	ΔR ±2.00%
Resistance to Solder Heat (Per MIL-STD-202, Method 210, Cond.B)	ΔR ±0.25%
Storage	-55°C to +125°C

Specifications subject to change without notice.

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications
MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

STANDARD RESISTANCE VALUES, OHMS

-3 Circuit (Isolated Resistors), -1 Circuit (Bussed Resistors)

Ohms	Code	Ohms	Code	Ohms	Code
22	220	1K	102	27K	273
33	330	1.2K	122	33K	333
39	390	1.5K	152	39K	393
47	470	1.8K	182	47K	473
56	560	2K	202	56K	563
68	680	2.2K	222	68K	683
82	820	2.7K	272	82K	823
100	101	3.3K	332	100K	104
120	121	3.9K	392	120K	124
150	151	4.7K	472	150K	154
180	181	5.6K	562	180K	184
220	221	6.8K	682	220K	224
270	271	8.2K	822	270K	274
330	331	10K	103	330K	334
390	391	12K	123	390K	394
470	471	15K	153	470K	474
560	561	18K	183	560K	564
680	681	20K	203	680K	684
820	821	22K	223	820K	824
				1Meg	105

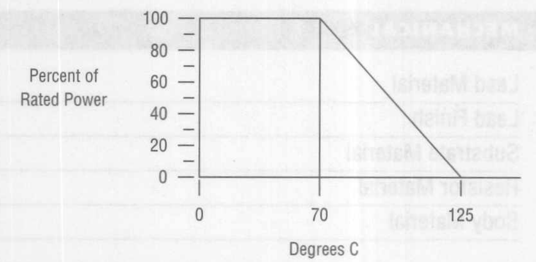
-5 Circuit (Dual Terminators)

Ohms	Code	Ohms	Code	Ohms	Code
R1/R2	R1/R2	R1/R2	R1/R2	R1/R2	R1/R2
180/390	181/391	330/390	331/391	3K/6.2K	302/622
220/270	221/271	330/470	331/471		
220/330	221/331	330/680	331/681		

POWER DISSIPATION, AT 70°C

Model	Per Package	Per Resistor
Tn-1	(n-1) x 0.100	0.100
Tn-3	(n-1) x 0.100	0.100
Tn-5	(n-1) x 0.100	0.060

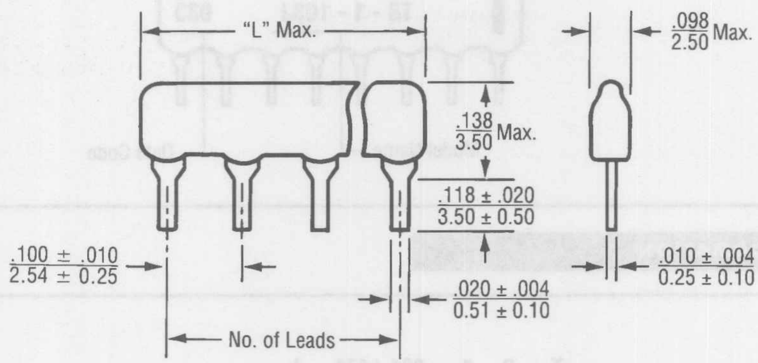
POWER DERATING CURVE



PACKAGING

Standard: Plastic Bags
Capacity = 200 Units

OUTLINE DIMENSIONS (Inch/mm)

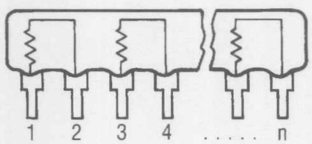


Package Length ("L")

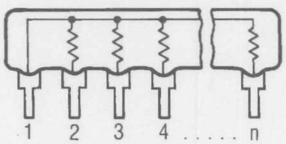
#of Leads		4	5	6	7	8	9	10	11	12	13	14
"L"	in.	.40	.50	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40
Max	mm	10.16	12.70	15.24	17.78	20.32	22.86	25.40	27.94	30.48	33.02	35.56

SCHEMATICS

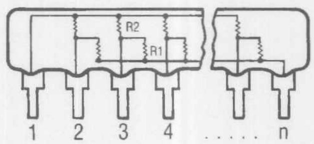
-3 Circuit
Isolated Resistors



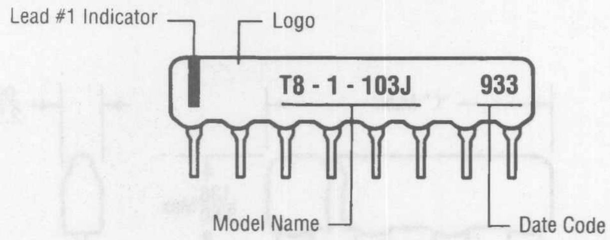
-1 Circuit
Bussed Resistors



-5 Circuit
Dual Terminator



TYPICAL PART MARKING



ORDERING INFORMATION

T 8 1 331 / 471 J

Model Series — T

No. of Leads: 4 thru 14 — 8

Circuit Type:
1 = Bussed
3 = Isolated
5 = Dual Terminator
— 1

Resistance Code
First 2 digits are significant
Last digit denotes number of trailing zeros
— 331

R2 Resistance Code
(Add for -5 circuit only)
— 471

Tolerance Code:
G = 2%
J = 5%
— J

MODEL 627, 628

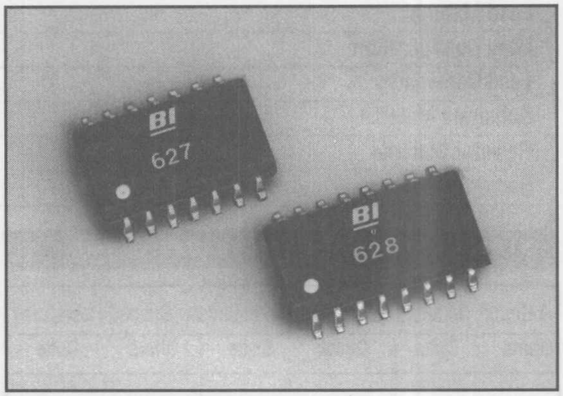
Surface Mount

Small Outline

Dual In-Line

Thick Film Resistor Network

Distributor Item



4

ELECTRICAL

Standard Resistance Range, Ohms	22 to 1Meg
Standard Resistance Tolerance, at 25°C	±2% (<33 Ohms = ±1Ohm)
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Temperature Coefficient of Resistance, Tracking	±50ppm/°C
Maximum Operating Voltage	50V dc or √PR
Insulation Resistance	≥10,000 Megohms

ENVIRONMENTAL

Thermal Shock plus Power Conditioning	ΔR 0.70%
Short Time Overload	ΔR 0.25%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Operation	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 2,000 Hours (≤33Ohms = ±0.5 Ohm)	ΔR 0.50%
Resistance to Solder Heat (Total immersion in solder at 280°C for 10 sec.)	ΔR 0.25%
Dielectric Withstanding Voltage	200V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Copper Alloy, 60/40 Tin-Lead (Dipped)
Lead Configuration	Gull Wing
Lead Coplanarity	±0.002 in. (0.051mm)
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Epoxy

STANDARD RESISTANCE VALUES, OHMS

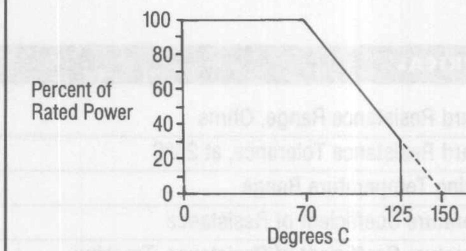
A Circuit (Isolated Resistors) and B Circuit (Bussed Resistors)

Ohms	Code	Ohms	Code	Ohms	Code
22	**220**	1.2K	122	39K	393
33	**330**	1.5K	152	**47K**	**473**
39	**390**	1.8K	182	56K	563
47	**470**	2K	202	68K	683
56	560	**2.2K**	**222**	82K	823
68	**680**	**2.7K**	**272**	**100K**	**104**
82	820	**3.3K**	**332**	120K	124
100	**101**	3.9K	392	150K	154
120	121	**4.7K**	**472**	180K	184
150	151	5.6K	562	220K	224
180	181	**6.8K**	**682**	270K	274
220	**221**	8.2K	822	330K	334
270	271	**10K**	**103**	390K	394
330	**331**	12K	123	470K	474
390	391	15K	153	560K	564
470	471	18K	183	680K	684
560	561	20K	203	820K	824
680	**681**	**22K**	**223**	**1Meg**	**105**
820	821	**27K**	**273**		
1K	**102**	33K	333		

J Circuit (Dual Terminators)

Ohms	Code	Marking	Ohms	Code	Marking
R1/R2	R1/R2		R1/R2	R1/R2	
100/150	101/151	33	330/330	331/331	32
180/270	181/271	30	**330/470**	**331/471**	**10**
180/300	181/301	31	3K/10K	302/103K	37
180/390	**181/391**	**06**	**3K/6.2K**	**330/622**	**13**
220/270	**221/271**	**07**	3.3K/6.8K	332/682	23
220/330	**221/331**	**08**	470/1K	471/102	36
270/470	271/471	21	680/1K	681/102	38
2.2K/5.6K	222/562	34	680/1.2K	681/122	22

POWER DERATING CURVE



POWER DISSIPATION, WATTS AT 70°C

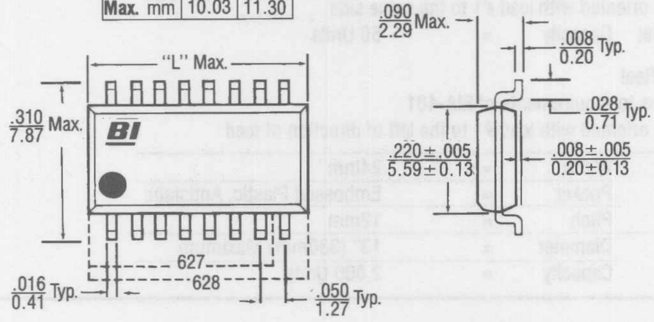
Model	Package	— Resistor (Per Circuit) — A	B	J
627	1.28	0.32	0.16	0.16
628	1.28	0.32	0.16	0.16

Resistance values represented in **Bold** face are stock standard values.

OUTLINE DIMENSIONS (Inch/mm)

Package Length ("L")

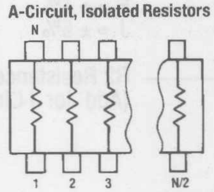
Model		627	628
"L" Max.	Inch	.395	.445
	mm	10.03	11.30



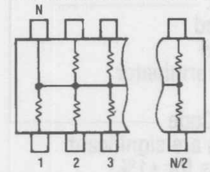
Note: Maximum allowable mold excursion = 0.006"

SCHEMATICS/SOLDER PAD LAYOUT (Inch/mm)

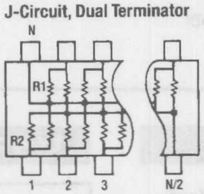
A-Circuit, Isolated Resistors



B-Circuit, Bussed Resistors

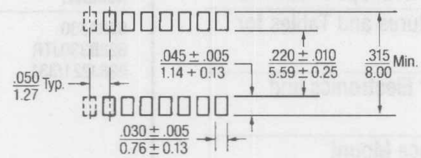


J-Circuit, Dual Terminator



627: N = 14 Leads 628: N = 16 Leads

Solder Pad Layout



4

PACKAGING

Standard:	Magazines			
	Conforms to EIA and JEDEC standards.			
	All units oriented with lead #1 to the same side			
	Magazine:	Capacity	=	50 Units
Option:	Tape & Reel			
	Conforms to requirements of EIA-481			
	All units oriented with lead #1 to the left of direction of feed			
Tape:	Width	=	24mm	
	Pocket	=	Embossed Plastic, Antistatic	
	Pitch	=	12mm	
Reel:	Diameter	=	13" (330mm) Maximum	
	Capacity	=	2,000 Units	

ORDERING INFORMATION

62 8 J 330 / 470 F TR4

- **62** — Model Series
- **8** — Number of Leads:
  7 = 14 Leads
  8 = 16 Leads
- **J** — Circuit Type:
  A = Isolated
  B = Bussed
  J = Dual Terminator
- **330** — Resistance Code
  First 2 digits are significant
  (First 3 digits for ±1%)
  Last digit denotes the number of trailing zeros
- **470** — R2 Resistance Code
  (Add for J Circuit only)
- **F** — Tolerance Code:
  (No code used for 2% std.)
  F = ± 1%
  J = ± 5%
- **TR4** — Tape & Reel Option

APPLICABLE DOCUMENTS

MIL-R-914 – Resistor Networks, Fixed, Film, Surface Mount Established Reliability General Specifications

MIL-STD-105 –Sampling Procedures and Tables for Inspection by Attributes

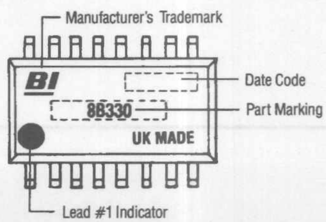
MIL-STD-202 –Test Methods for Electronics and Electrical Component Parts

EIA-481– Carrier Taping of Surface Mount Components for Automatic Handling

EIA-PDP-100 – SOGN-0002 Outline Dimensions

TYPICAL PART MARKING

Part Number:	Part Marking:
628A330	8A330
628B330JTR	8B330J
628J221/331	8J08



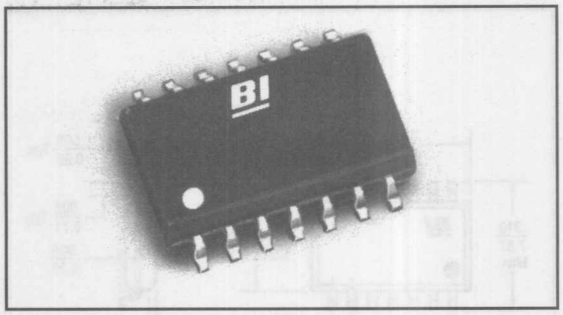
MODEL 627 T

Surface Mount

CCITT V.35 Termination

Network

NEW PRODUCT



ELECTRICAL

Standard Resistance Tolerance, at 25°C	±2%
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±250ppm/°C
Temperature Coefficient of Resistance Tracking	±50ppm/°C
Voltage Coefficient of Resistance	±100ppm/°C
Maximum Operating Voltage	25V dc
Insulation Resistance	≥10,000 Megohms

4

ENVIRONMENTAL

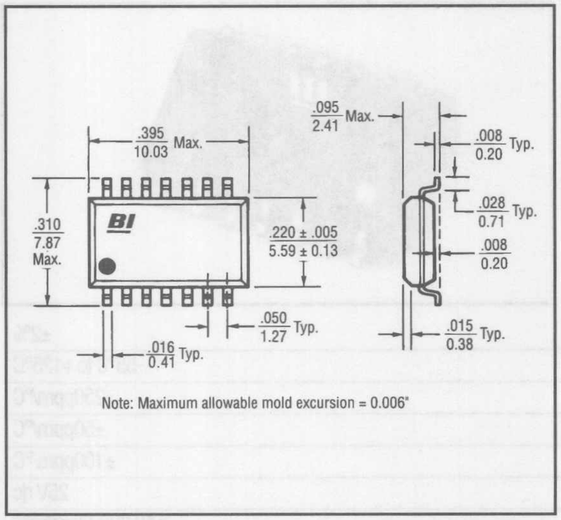
Thermal Shock plus Power Conditioning	ΔR 0.70%
Short Time Overload	ΔR 0.25%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration Shock	ΔR 0.25%
Low Temperature Operation	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 2,000 Hours (≤33 Ohms = ±0.5 Ohm)	ΔR 0.50%
Resistance to Solder Heat (Total immersion in solder at 280°C for 10 sec.)	ΔR 0.25%
Dielectric Withstanding Voltage	200V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

MECHANICAL

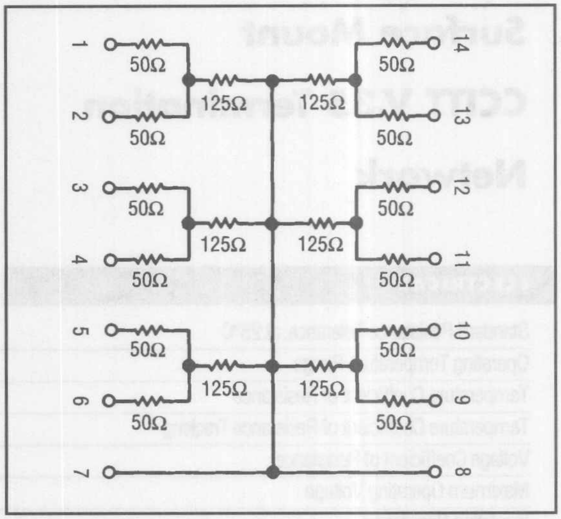
Lead Material	Copper Alloy, 60/40 Tin-Lead (Dipped)
Lead Configuration	Gull Wing
Lead Coplanarity	±0.002 in. (0.057mm)
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Epoxy

Specifications subject to change without notice.

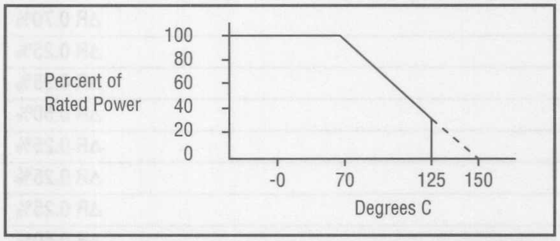
OUTLINE DIMENSIONS (Inch/mm)



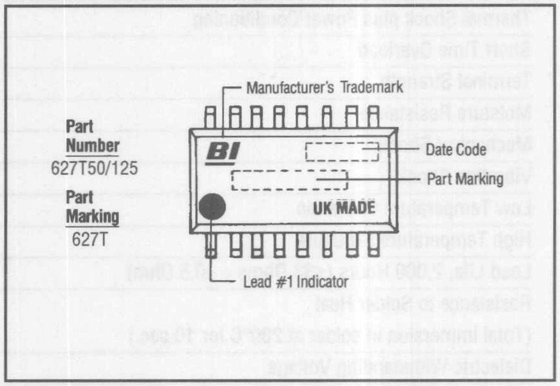
SCHEMATIC



POWER DERATING CURVE



TYPICAL PART MARKING



POWER DISSIPATION, WATTS AT 70°C

Model	Package	Per Resistor
627 T	1.28	0.25

ORDERING INFORMATION

62 7 T 500 / 1250 TR4

- 62 — Model Series
- 7 — No. of Leads: 7 = 14 leads
- T — Circuit Type: T = V.35 Termination
- 500 / 1250 — Resistance Values
- TR4 — Tape & Reel Option: 4 = 24mm

PACKAGING

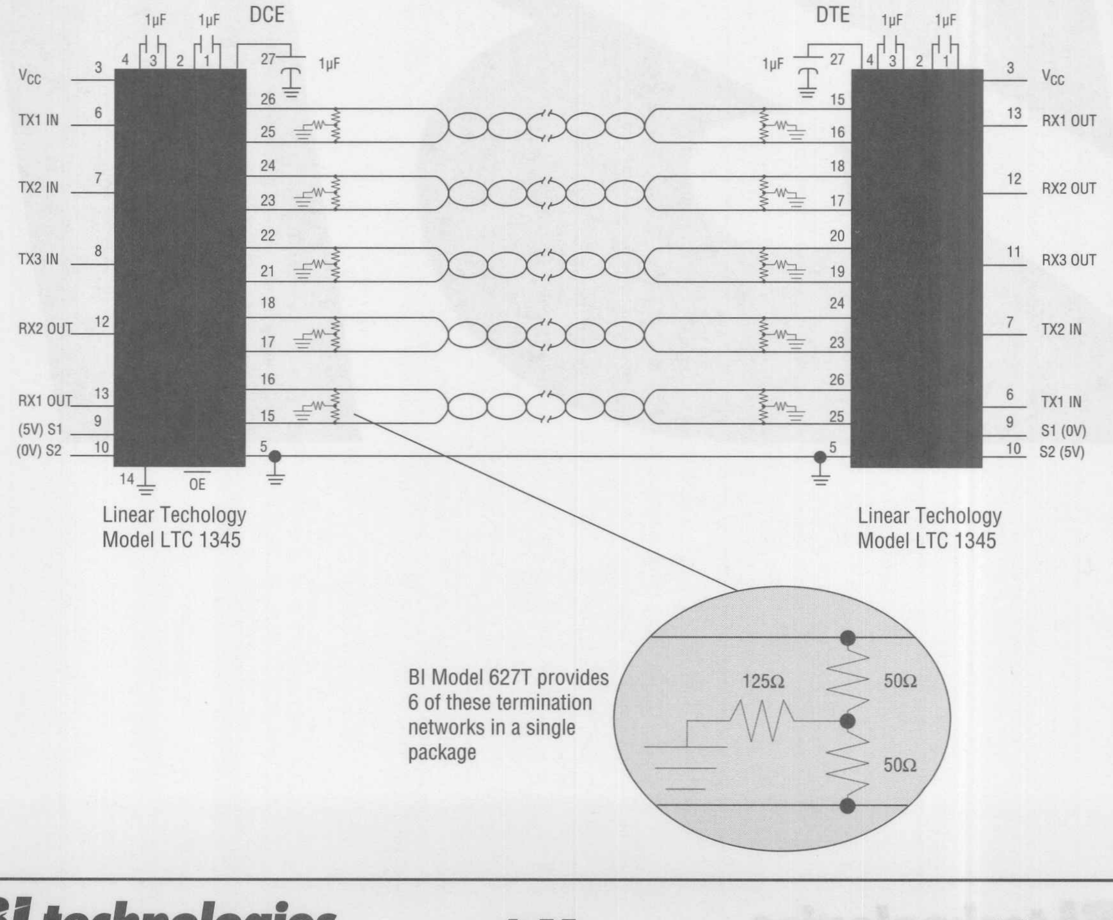
Standard: Magazines
Conforms to EIA and JEDEC standards
All units oriented with lead #1 to the same side
Magazine: Capacity = 50 Units

Option: Tape & Reel (Per EIA-481)
Conforms to requirements of EIA-481
All units oriented with lead #1 to the left of direction of feed

Tape	Width	=	24mm
	Pocket	=	Embossed Antistatic Plastic
	Pitch	=	12mm
Reel	Diameter	=	13" (330mm) Maximum
	Capacity	=	2,000 Units

TYPICAL APPLICATION

V.35 Balanced Interface



MODEL 627 V100

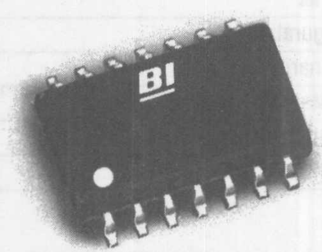
Surface Mount

Resistor Network

Designed For

Pentium® Power Supply

NEW PRODUCT



4

APPLICATION

Designed for P54C, P54C-VR and P54C-VRE Pentium® Processors when used in conjunction with Linear Technology Models LT 1266/1267 or LT 1584/1585 voltage regulator IC's.

ELECTRICAL

Standard Resistance Tolerance, at 25°C	±2%
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±100ppm/°C
Temperature Coefficient of Resistance Tracking	50ppm/°C
Voltage Coefficient of Resistance	±100ppm/V
Maximum Operating Voltage	25V dc
Insulation Resistance, Minimum	10,000 Megohms

ENVIRONMENTAL (PER MIL-R-83401)

Thermal Shock plus Power Conditioning	ΔR 0.70%
Short Time Overload	ΔR 0.25%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration Shock	ΔR 0.25%
Low Temperature Operation	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 2,000 Hours (≤33 Ohms = ±0.5 Ohm)	ΔR 0.50%
Resistance to Solder Heat	ΔR 0.25%
Dielectric Withstanding Voltage	200V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

Specifications subject to change without notice.
Pentium® is a registered trademark of Intel Corporation.

MECHANICAL

Lead Material	Copper Alloy, 60/40 Tin-Lead (Dipped)
Lead Configuration	Gull Wing
Lead Coplanarity	±0.002 in. (0.057mm)
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Epoxy

PACKAGING

Standard: Magazines
Conforms to EIA and JEDEC standards
All units oriented with lead #1 to the same side
Magazine: Capacity = 50 Units

Option: Tape & Reel
Conforms to requirements of EIA-481
All units oriented with lead #1 to the left of direction of feed

Tape	Width	=	24mm
	Pocket	=	Embossed Plastic, Antistatic
	Pitch	=	12mm
Reel	Diameter	=	13" (330mm) Maximum
	Capacity	=	2,000 Units

ORDERING INFORMATION

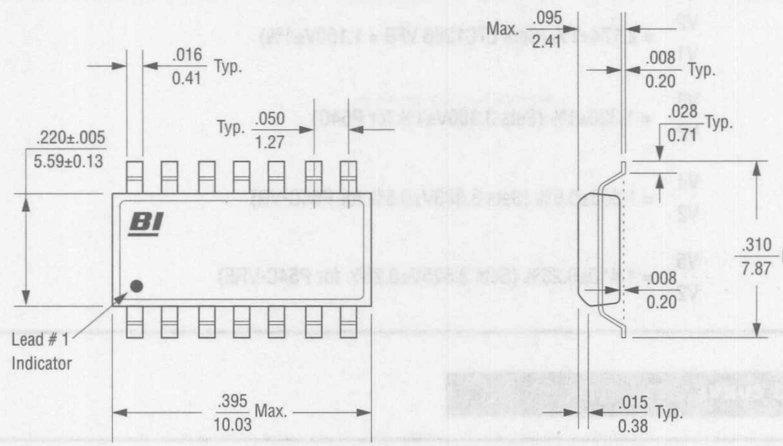
627 V100 TR4

Model Series — 627

Tape & Reel Option:
4 = 24mm

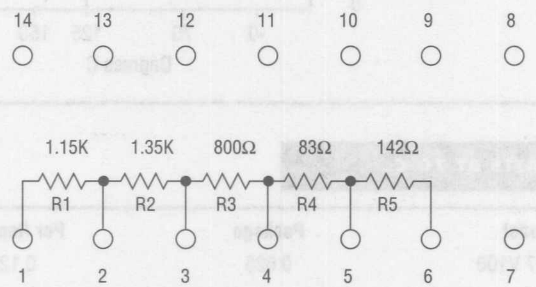
Circuit Type:
V100 = Pentium®
Resistor Network

OUTLINE DIMENSIONS (Inch/mm)

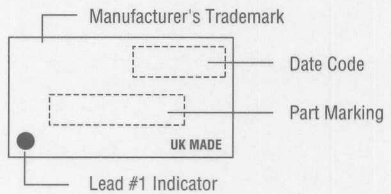


Note: Maximum allowable mold excursion = 0.006"

SCHEMATIC



TYPICAL PART MARKING



Part Marking:
627V100

MATCHING (VOLTAGE RATIO)

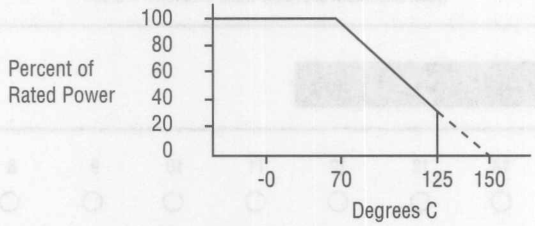
$$\frac{V2}{V1} = 2.174 \pm 1\% \text{ (Sets LTC1266 VFB = 1.150V} \pm 1\%)$$

$$\frac{V3}{V2} = 1.320 \pm 1\% \text{ (Sets 3.300V} \pm 1\% \text{ for P54C)}$$

$$\frac{V4}{V2} = 1.353 \pm 0.5\% \text{ (Sets 3.383V} \pm 0.5\% \text{ for P54C-VR)}$$

$$\frac{V5}{V2} = 1.410 \pm 0.25\% \text{ (Sets 3.525V} \pm 0.25\% \text{ for P54C-VRE)}$$

POWER DERATING CURVE



POWER DISSIPATION, WATTS AT 70°C

Model	Package	Per Resistor
627 V100	0.625	0.125

MODEL 628 L

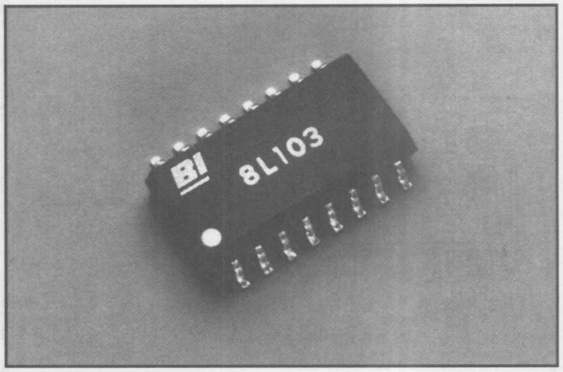
R/2R Ladder

Surface Mount

Small Outline

Dual In-Line

Thick Film Resistor Network



ELECTRICAL

Standard Resistance Range, Ohms	10K to 100K
Standard Resistance Tolerance, at 25°C	±2%
Operating Temperature Range	0°C to 70°C
Temperature Coefficient of Resistance	±100ppm/°C
Maximum Operating Voltage	50V dc or √PR
Insulation Resistance	≥10,000 Megohms
Ladder Network Accuracy	8 Bits ±1/2 LSB, 0° to 70°

MECHANICAL

Lead Material	Copper Alloy, 60/40 Tin-Lead (Dipped)
Lead Configuration	Gull Wing
Lead Coplanarity	±0.002 in. (0.057mm)
Substrate Material	Alumina
Resistor Material	Cermet
Body Material	Epoxy

APPLICABLE DOCUMENTS

MIL-R-914 — Resistor Networks, Fixed, Film, Surface Mount Established Reliability General Specification

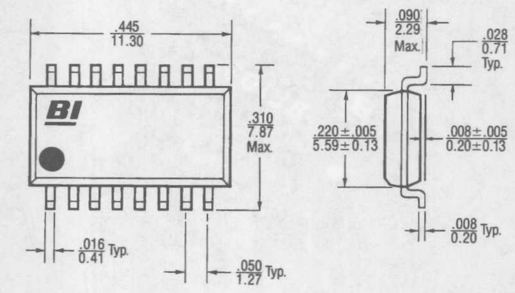
MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

EIA-481 — Carrier Taping of Surface Mount Components for Automatic Handling

EIA-PDP-100 — SOGN-0002 Outline Dimensions

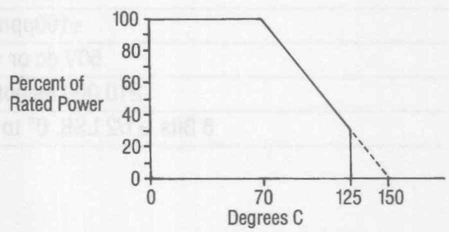
Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)



Note: Maximum allowable mold excursion = 0.006"

POWER DERATING CURVE



POWER DISSIPATION, WATTS AT 70°C

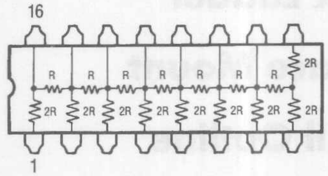
Model	Per Package	Per Resistor
628L	0.640	0.040

STANDARD RESISTANCE VALUES, OHMS

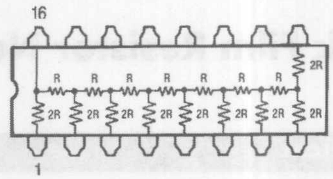
R/2R	R/2R	R/2R
10K/20K	25K/50K	100K/200K
	50K/100K	

SCHEMATICS/SOLDER PAD LAYOUT

Model 628L (8 Bits) (16 Leads)

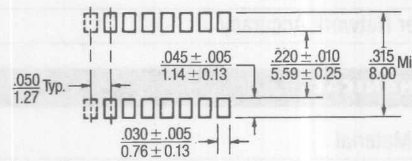


Model 628LN (8 Bits) (16 Leads)

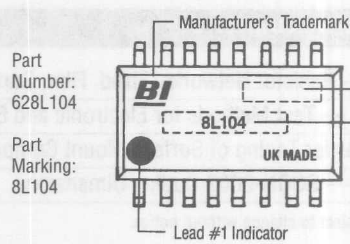


Consult factory for custom circuit

Solder Pad Layout



TYPICAL PART MARKING



PACKAGING

Standard: Magazines
Conforms to EIA and JEDEC standards.
All units oriented with lead #1 to the same side
Magazine: Capacity = 50 Units

Option: Tape & Reel
Conforms to requirements of EIA-481
All units oriented with lead #1 to the left of direction of feed

Tape:	Width	=	24mm
	Pocket	=	Embossed Plastic, Antistatic
	Pitch	=	12mm
Reel:	Diameter	=	13" (330mm) Maximum
	Capacity	=	2,000 Units

ORDERING INFORMATION

628 L 104 TR4

Model Series — 628

Circuit Type: L = Ladder — L

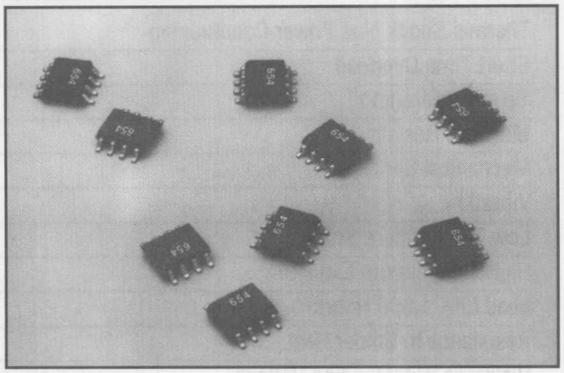
R Resistance Code — 104
First 2 digits are significant
Last digit denotes the number of trailing zeros

Tape & Reel Option — TR4

4

MODEL 654

RF Attenuator
Surface Mount
Precision Thin Film
Resistor Network



ELECTRICAL

Impedance	50 Ohm
Operating Temperature Range	-55°C to +125°C
Resistance Voltco	≈0
Temperature Coefficient	±25ppm/°C
Operating Voltage, Maximum	100V dc or √PR
Insulation Resistance	≥10,000 Megohms
Noise, Maximum (MIL-STD-202, Method 308)	-40dB

PERFORMANCE

Frequency	DC to 500MHZ	500MHz to 1GHz
VSWR	1.05 Max.	1.10 Max.
Attenuation Accuracy	±0.1dB Max.	±0.2dB Max.
Frequency Flatness	±0.1dB Max.	±0.2dB Max.
Phase Shift	±10° Max.	±20° Max.

MECHANICAL

Lead Plating	85/15 Tin Lead
Lead Material	Copper Alloy
Lead Configuration	Gull Wing
Lead Coplanarity	0.004" (0.102mm)
Substrate Material	Alumina
Resistor Material	Nichrome
Body Material	Molded Epoxy

Specifications subject to change without notice.

4

ENVIRONMENTAL

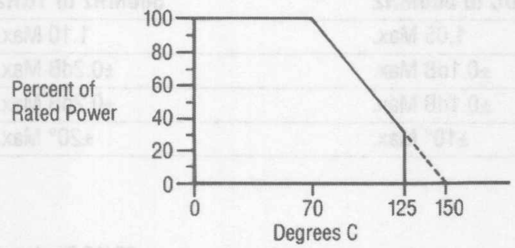
Thermal Shock plus Power Conditioning	ΔR 0.25%
Short Time Overload	ΔR 0.10%
Terminal Strength	ΔR 0.10%
Moisture Resistance	ΔR 0.20%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.10%
High Temperature Exposure	ΔR 0.10%
Load Life, 1,000 Hours	ΔR 0.10%
Resistance to Solder Heat	ΔR 0.10%
Dielectric Withstanding Voltage	100V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	per MIL-STD-202, Method 215
Lead Solderability	per MIL-STD 202, Method 208
Flammability	UL-94V-O Rated
Storage	-65°C to +125°C

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

MIL-STD-202 — Test Methods for Electronics and Electrical Component Parts

POWER DERATING CURVE



STANDARD ATTENUATION VALUES*

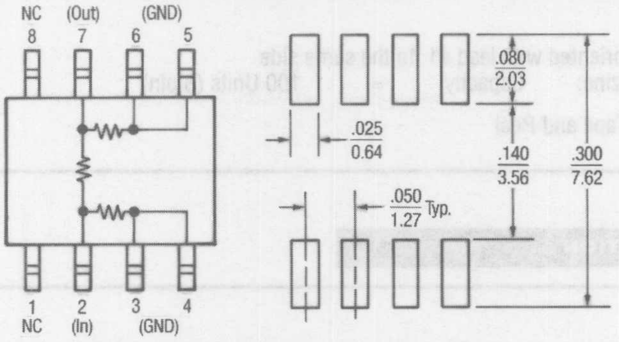
2dB	6dB	12dB
3dB	8dB	14dB
4dB	10dB	16dB

* Consult factory for other values

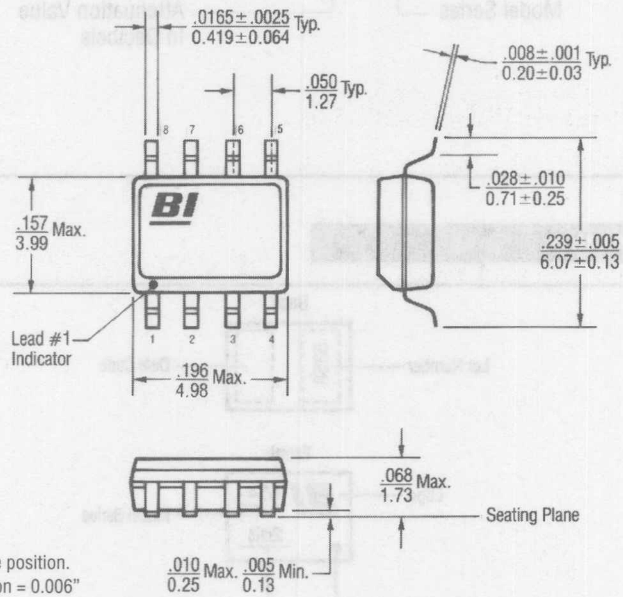
POWER (WATTS) DISSIPATION AT 70° C

Model	Package
654	.4

SCHEMATIC/SOLDER PAD LAYOUT



OUTLINE DIMENSIONS (Inch/mm)



Notes:
1. Leads are within .005/0.13 of true position.
2. Maximum allowable mold excusion = 0.006"

PACKAGING

Standard: Magazines

All units oriented with lead #1 to the same side

Magazine: Capacity = 100 Units (8 pin)

Option: Embossed Tape and Reel

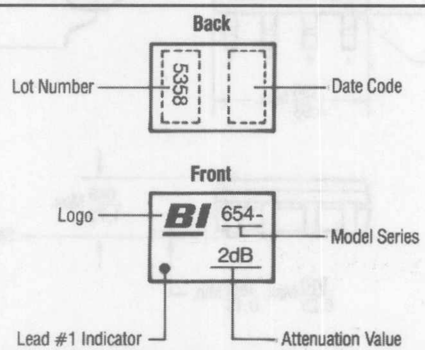
ORDERING INFORMATION

654 2dB

Model Series — 654

Attenuation Value In Decibels — 2dB

TYPICAL PART MARKING



MODELS

664, 667, 668

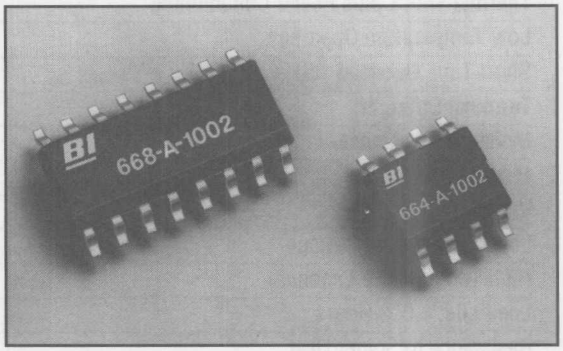
Surface Mount

.150" Dual In-Line

Precision Thin Film

Resistor Network

Distributor Item



4

ELECTRICAL

Operating Temperature Range	-55°C to +125°C
Resistance Voltco	≈0
Interlead Capacitance	<2pF
Operating Voltage, Maximum	100V dc or √PR
Insulation Resistance	≥10,000 Megohms
Noise, Maximum (MIL-STD-202, Method 308)	-40dB

MECHANICAL

Lead Plating	85/15 Tin Lead
Lead Material	Copper Alloy
Lead Configuration	Gull Wing
Lead Coplanarity	0.004" (0.102mm)
Substrate Material	Alumina
Resistor Material	Nichrome
Body Material	Molded Epoxy

TOLERANCES

Accuracy Code *	A	B	D	F
Absolute Resistance Tolerances, At 25°C	0.1%	0.1%	0.5%	1.0%
Ratio	0.05%	0.1%	0.1%	0.5%
Temperature Coefficient of Resistance				±25ppm/°C
Temperature Coefficient of Resistance, Tracking				±5ppm/°C

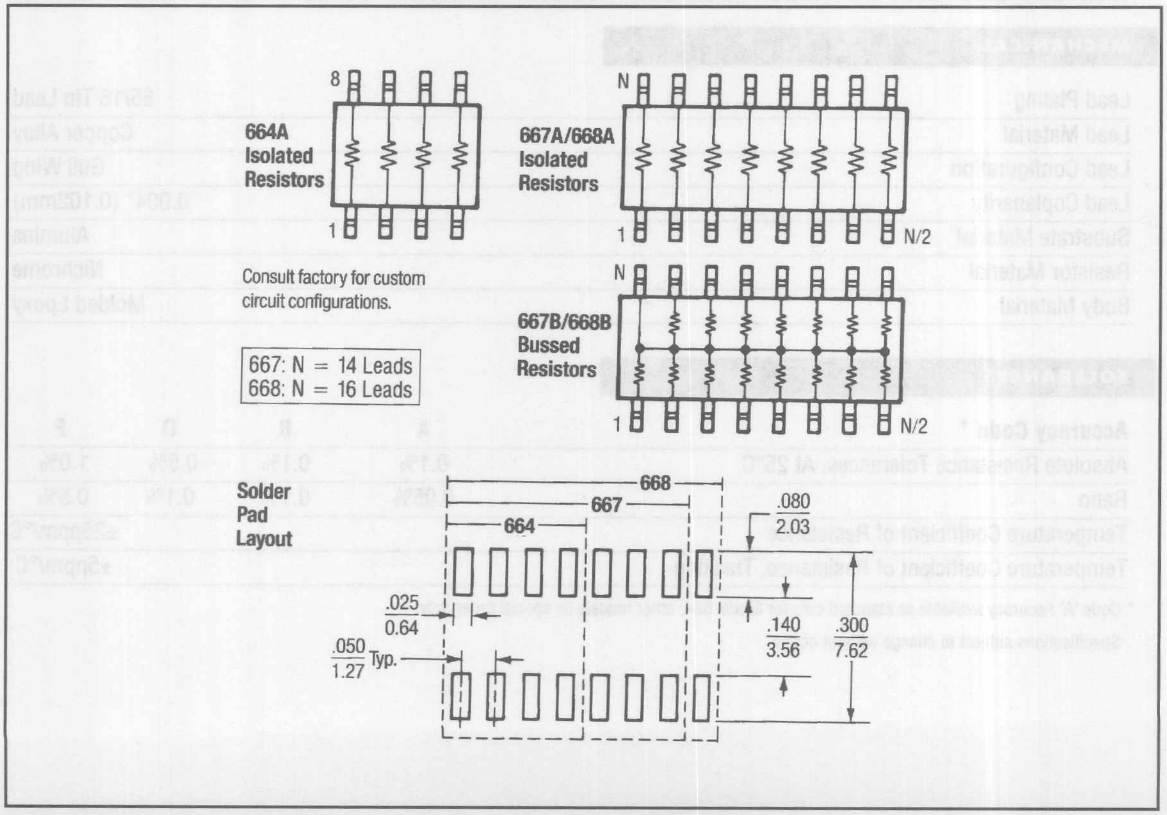
* Code 'A' Accuracy available as standard only for Model 664; other models by special order only.

Specifications subject to change without notice.

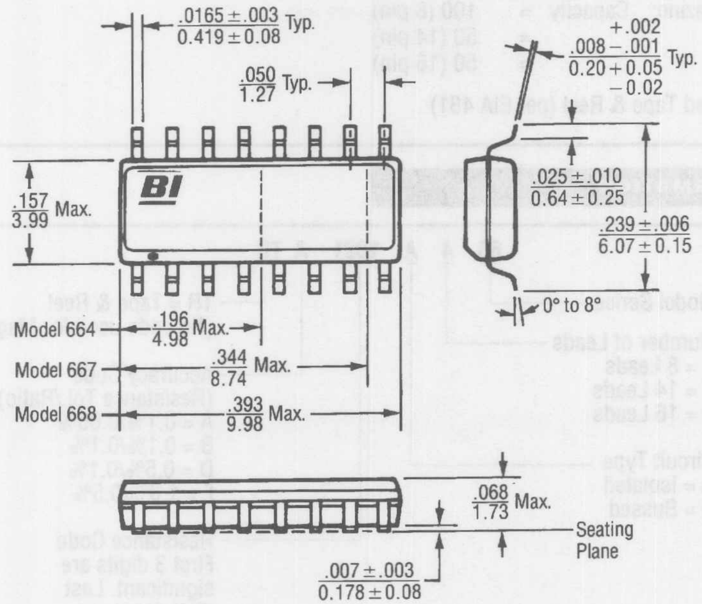
ENVIRONMENTAL

Thermal Shock plus Power Conditioning	ΔR 0.25%
Low Temperature Operation	ΔR 0.10%
Short Time Overload	ΔR 0.10%
Terminal Strength	ΔR 0.10%
Moisture Resistance	ΔR 0.20%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.10%
High Temperature Exposure	ΔR 0.10%
Load Life, 1,000 Hours	ΔR 0.10%
Resistance to Solder Heat	ΔR 0.10%
Dielectric Withstanding Voltage	100V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-65°C to +125°C

SCHEMATIC/SOLDER PAD LAYOUT (Inch/mm)

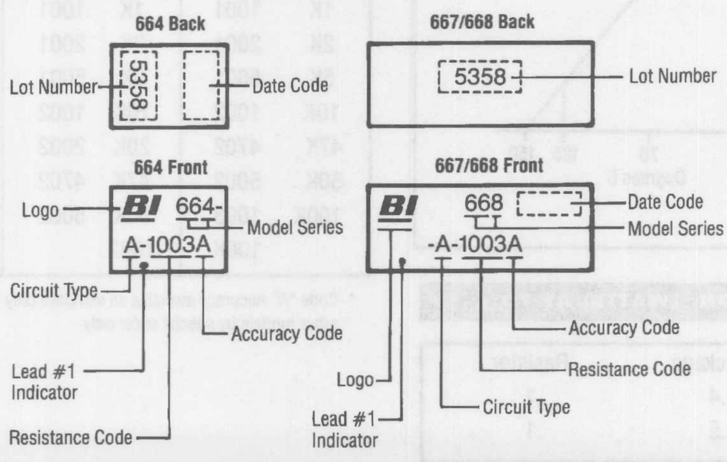


OUTLINE DIMENSIONS (Inch/mm)



Notes:
1.Leads are within .005/0.13 of the true position.
2. Maximum allowable mold excursion = 0.006"

TYPICAL PART MARKING



PACKAGING

Standard: Magazines
All units oriented with lead #1 to the same side
Magazine: Capacity = 100 (8 pin)
= 50 (14 pin)
= 50 (16 pin)

Option: Embossed Tape & Reel (per EIA 481)

ORDERING INFORMATION

66 4 A 1001 A TR

Model Series — 66

Number of Leads — 4
4 = 8 Leads
7 = 14 Leads
8 = 16 Leads

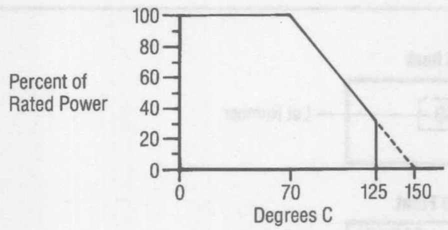
Circuit Type — A
A = Isolated
B = Bussed

Resistance Code — 1001
First 3 digits are significant. Last digit denotes the number of trailing zeros.

Accuracy Code — A
(Resistance Tol./Ratio)
A = 0.1%/0.05%
B = 0.1%/0.1%
D = 0.5%/0.1%
F = 1.0%/0.5%

TR = Tape & Reel
(No code used for Magazines)

POWER DERATING CURVE



POWER DISSIPATION, (WATTS) AT 70°C

Model	Package	Resistor
664	.4	.1
667/668	.5	.1

STANDARD RESISTANCE VALUES, OHMS

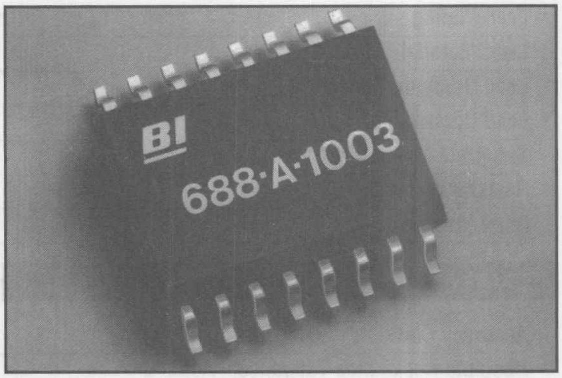
664A		667A, 668A		667B, 668B	
Ohms	Code	Ohms	Code	Ohms	Code
1K	1001	1K	1001	10K	1002
2K	2001	2K	2001	20K	2002
5K	5001	5K	5001		
10K	1002	10K	1002		
47K	4702	20K	2002		
50K	5002	47K	4702		
100K	1003	50K	5002		
		100K	1003		

* Code "A" Accuracy available as standard only for Model 664, other models by special order only.

MODEL 688

Surface Mount
.300" Dual In-Line
Precision Thin Film
Resistor Network

Distributor Item



ELECTRICAL

Operating Temperature Range	-55°C to +125°C
Resistance Voltco	≈0
Interlead Capacitance	<2pF
Operating Voltage, Maximum	100V dc or √PR
Insulation Resistance	≥10,000 Megohms
Noise, Maximum (Mil-Std-202, Method 308)	-40dB

ENVIRONMENTAL

Thermal Shock plus Power Conditioning	ΔR 0.25%
Short Time Overload	ΔR 0.10%
Terminal Strength	ΔR 0.10%
Moisture Resistance	ΔR 0.20%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.10%
High Temperature Exposure	ΔR 0.10%
Load Life, 1,000 Hours	ΔR 0.10%
Resistance to Solder Heat	ΔR 0.10%
Dielectric Withstanding Voltage	100V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215)
Lead Solderability	MIL-STD-202, Method 208)
Flammability	UL-94V-O Rated
Storage	-65°C to +125°C

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

MIL-STD-202 — Test Methods for Electronics and Electrical Component Parts

Specifications subject to change without notice.

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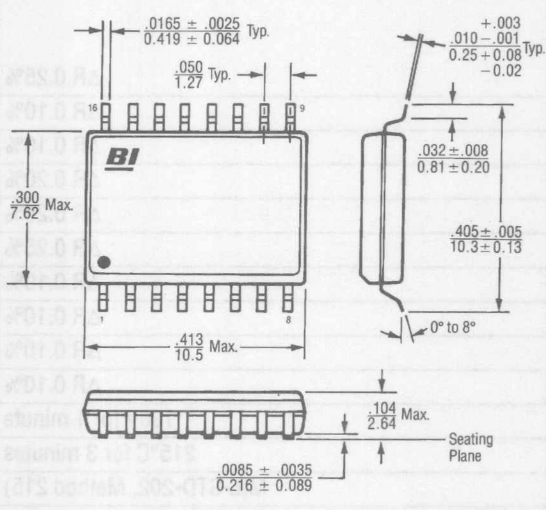
MECHANICAL

Lead Plating	85/15 Tin Lead
Lead Material	Copper Alloy
Lead Configuration	Gull Wing
Lead Coplanarity	0.004" (0.102mm)
Substrate Material	Alumina
Resistor Material	Nichrome
Body Material	Molded Epoxy

TOLERANCES

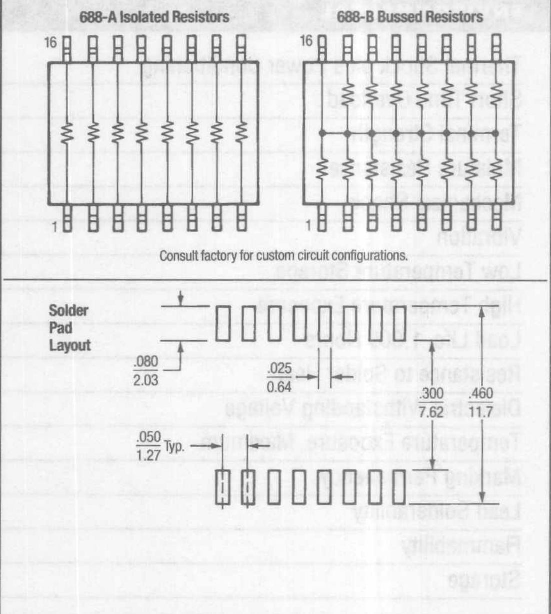
Accuracy Code	B	D	F
Absolute Resistance Tolerances, At 25°C	0.1%	0.5%	1.0%
Ratio	0.1%	0.1%	0.5%
Temperature Coefficient of Resistance	±25ppm/°C		
Temperature Coefficient of Resistance, Tracking	±5ppm/°C		

OUTLINE DIMENSIONS (Inch/mm)



Notes:
1. Leads are within .005/0.13 of true position
2. Maximum allowable mold excursion = 0.006"

SCHEMATICS/SOLDER PAD LAYOUT (Inch/mm)



ORDERING INFORMATION

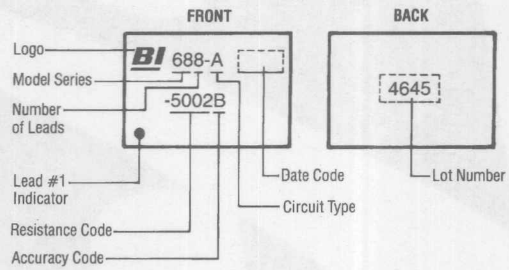
68 8 A 5002 B TR

- Model Series — 68
- Number of Leads — 8 = 16 Leads
- Circuit Type — A = Isolated, B = Bussed
- Resistance Code — First 3 digits are significant. Last digit denotes the number of trailing zeros
- Accuracy Code — B
- TR = Tape & Reel (No code used for Magazines)

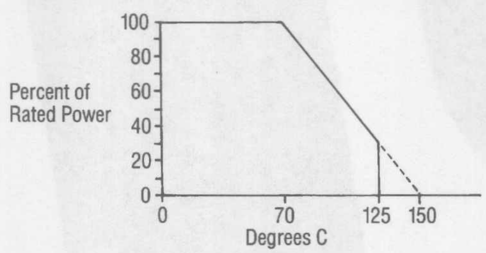
STANDARD RESISTANCE VALUES, OHMS

Model	Ohms	Code
688A	50K	5002
	100K	1003
688B	100K	1003

TYPICAL PART MARKING



POWER DERATING CURVE



PACKAGING

Standard: Magazines
All units oriented with lead #1 to the same side
Magazine: Capacity = 50 Units

Option: Embossed Tape & Reel

POWER DISSIPATION, (WATTS) AT 70°C

Model	Package	Resistor
688	.7	.1

MODEL

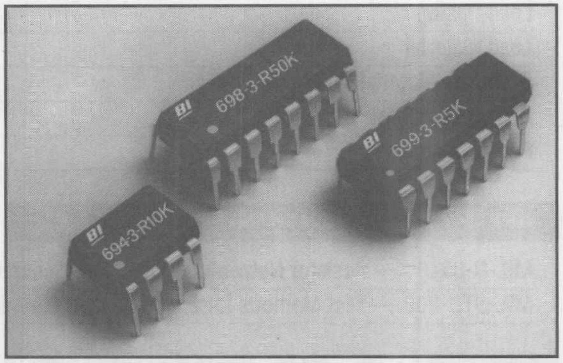
694, 698, 699

Dual In-Line

Precision Thin Film

Resistor Network

Distributor Item



4

ELECTRICAL

Operating Temperature Range	-55°C to +125°C
Resistance Voltco	≈0
Interlead Capacitance	<2pF
Operating Voltage, Maximum	100V dc or $\sqrt{PR}$
Insulation Resistance	≥10,000 Megohms
Noise, Maximum (MIL-STD-202, Method 308)	-40dB

ENVIRONMENTAL (PER MIL-R-83401)

Thermal Shock plus Power Conditioning	ΔR ±0.25%
Short Time Overload	ΔR ±0.10%
Terminal Strength	ΔR ±0.10%
Moisture Resistance	ΔR ±0.20%
Mechanical Shock	ΔR ±0.25%
Vibration	ΔR ±0.25%
Low Temperature Storage	ΔR ±0.10%
High Temperature Exposure	ΔR ±0.10%
Load Life, 1,000 Hours	ΔR ±0.10%
Resistance to Solder Heat	ΔR ±0.10%
Dielectric Withstanding Voltage	200V rms for 1 minute
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-65°C to +125°C

ACCURACY CODES

Code	A	B	D	F
Absolute Resistance Tolerances, At 25°C	0.1%	0.1%	0.5%	1.0%
Ratio	0.05%	0.1%	0.1%	0.5%
Temperature Coefficient of Resistance				±50ppm/°C
Temperature Coefficient of Resistance, Tracking				±5ppm/°C

Specifications subject to change without notice.

MECHANICAL

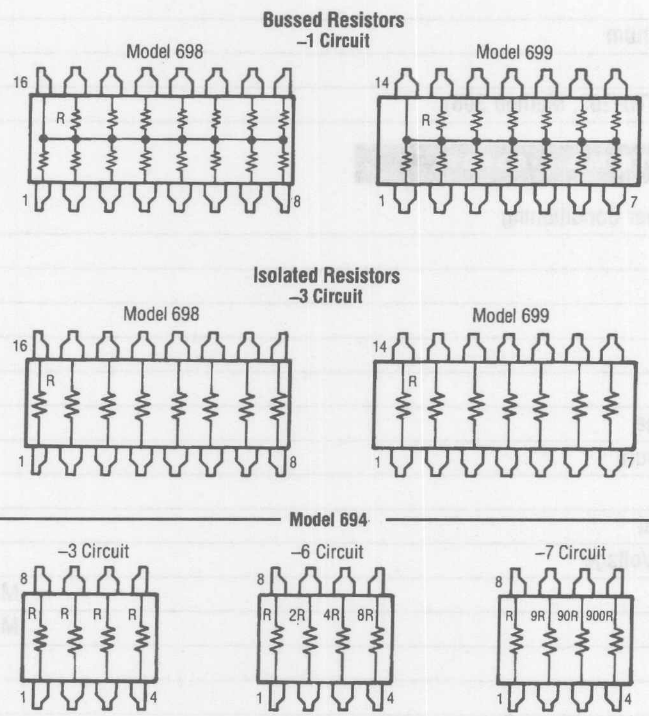
Lead Plating	60/40 Tin Lead (Dipped)
Lead Material	Copper Alloy
Substrate Material	Alumina
Resistor Material	Nichrome
Body Material	Molded Epoxy

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

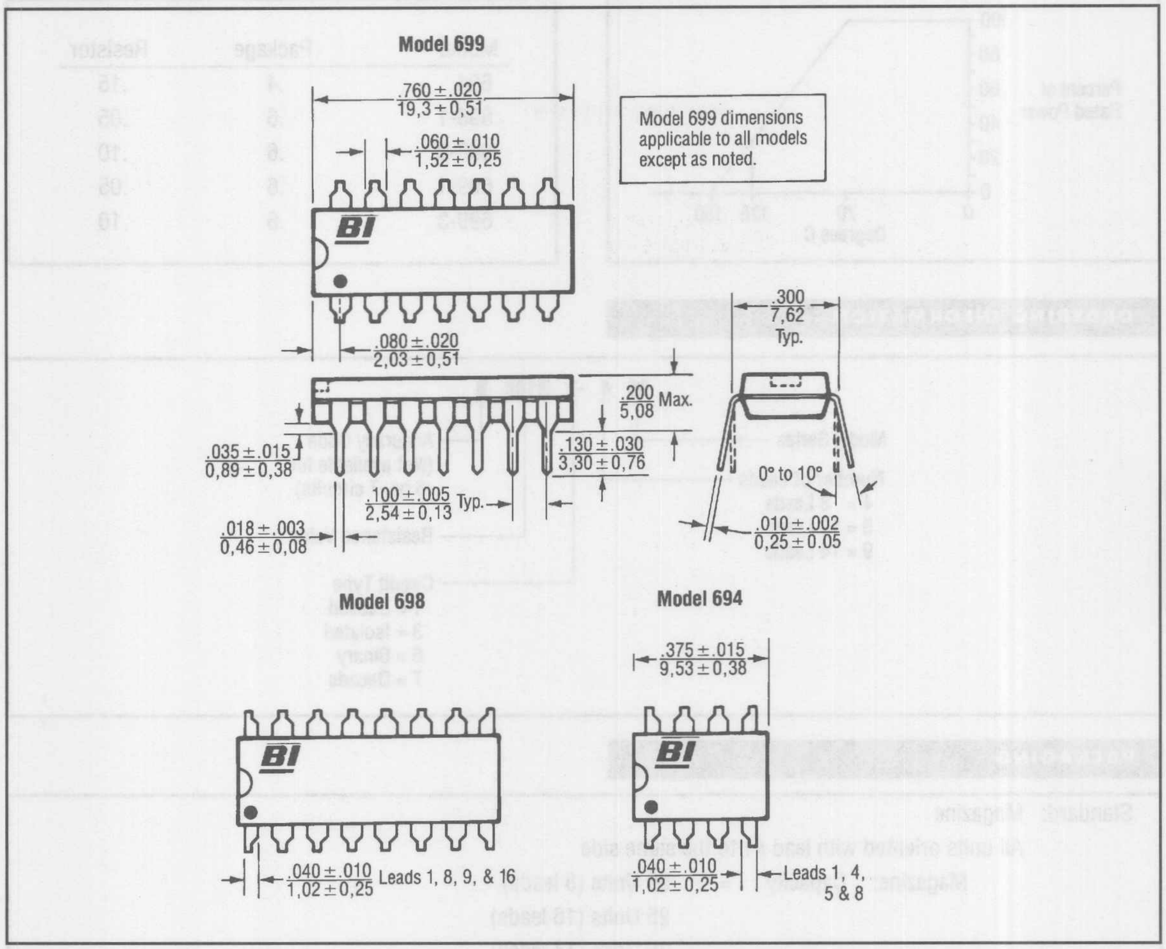
MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

SCHEMATICS

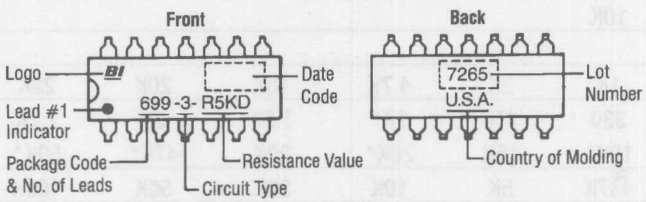


-6 & -7 circuits available only in .1% Absolute, .1% Ratio.

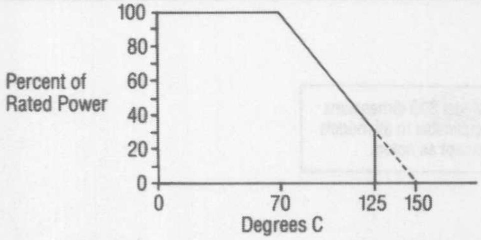
OUTLINE DIMENSIONS (Inch/mm)



TYPICAL PART MARKING



POWER DERATING CURVE



POWER (WATTS) DISSIPATION, AT 70°C

Model	Package	Resistor
694	.4	.15
698-1	.6	.05
698-3	.6	.10
699-1	.6	.05
699-3	.6	.10

ORDERING INFORMATION

69 4 -3 R10K B

- Model Series — 69
- Number of Leads — 4
  - 4 = 8 Leads
  - 8 = 16 Leads
  - 9 = 14 Leads
- Circuit Type — -3
  - 1 = Bussed
  - 3 = Isolated
  - 6 = Binary
  - 7 = Decade
- Resistance Value — R10K
- Accuracy Code (Not available for -6 or -7 circuits) — B

PACKAGING

Standard: Magazine

All units oriented with lead #1 to the same side

Magazine: Capacity = 50 Units (8 leads)

25 Units (16 leads)

25 Units (14 leads)

STANDARD RESISTANCE VALUES, OHMS*

694-3:	100*	500*	1K*	2K*	5K*	10K*	20K*	50K	100K*
694-6:	1K	10K							
697-7:	1K								
698-1:	470	1K	2K	4.7K	10K	20K	22K	47K	100K
698-3:	100	330	470	1K*	1.5K	2K	2.2K	3.3K	4.7K
	5K	10K*	15K	20K*	22K	47K*	50K*	100K*	
699-1:	1K	437K	5K	10K	20K	50K	100K		
699-3:	1K	2K	3.3K	4.7K	5K	10K	20K	22K	47K
	50K	100K							

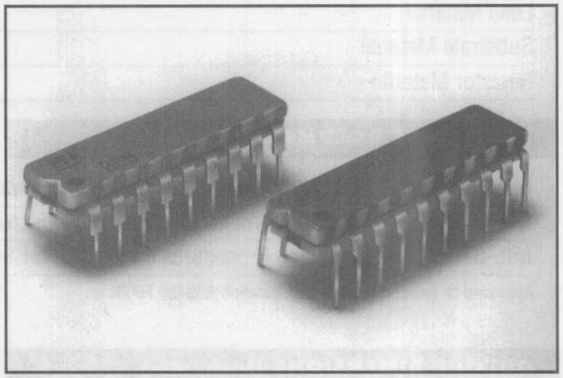
All values available in Accuracy codes B, D, F. except -6 or -7 circuits.
Values with an * are also available in Accuracy code A.
Consult factory for additional values.

MODEL 888, 887

18 & 20 Pin

Dual In-Line

Thick Film Resistor Network



4

ELECTRICAL

Standard Resistance Range, Ohms	22 to 2.2Meg
Standard Resistance Tolerance, at 25°C	±2% (<100 Ohms = ±2 Ohms)
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Temperature Coefficient of Resistance Tracking	±50ppm/°C
Maximum Operating Voltage	100V dc or √PR
Insulation Resistance	≥10,000 Megohms

ENVIRONMENTAL (PER MIL-R-83401)

Thermal Shock plus Power Conditioning	ΔR 0.70%
Short Time Overload	ΔR 0.50%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 1,000 Hours	ΔR 1.00%
Resistance to Solder Heat (Per MIL-STD-202, Method 210, Cond.B)	ΔR 0.25%
Dielectric Withstanding Voltage	200V for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Copper Alloy, 60/40 Tin-Lead (Plating)
Substrate Material	Alumina
Resistor Material	Cermet

APPLICABLE DOCUMENTS

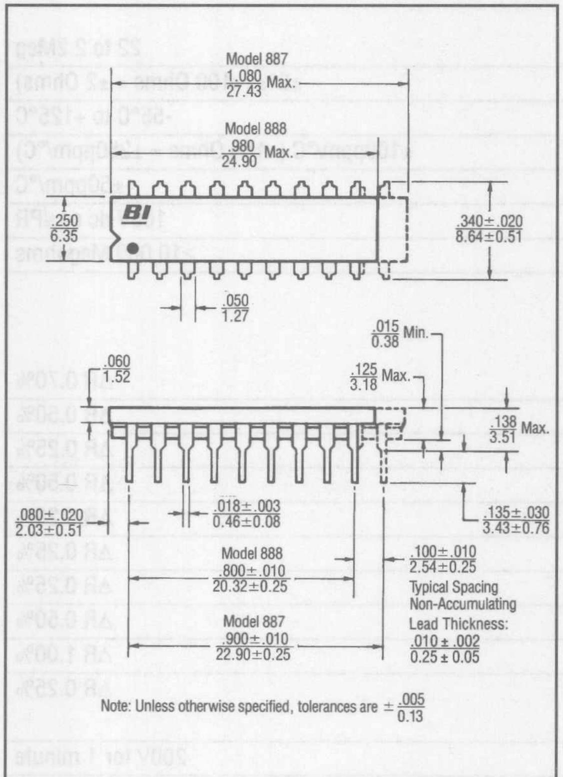
MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

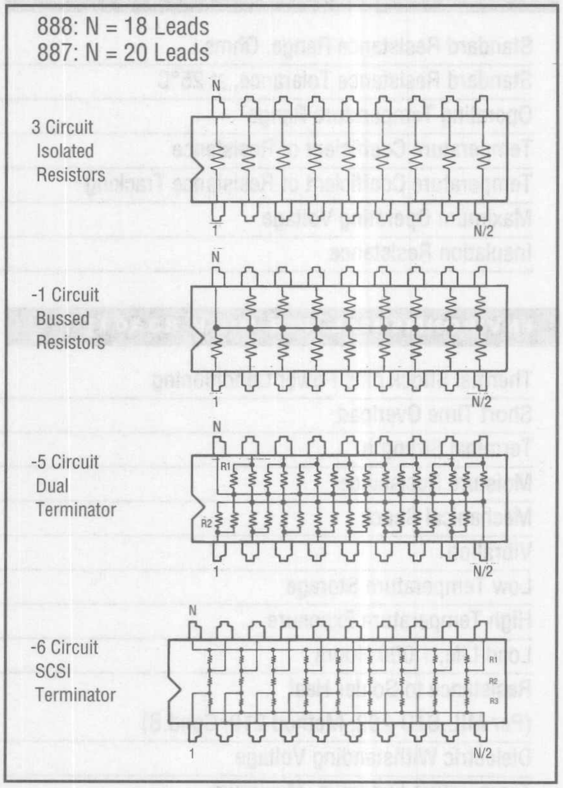
MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes

Approved to British Standard Specification BS9450 F0001

OUTLINE DIMENSIONS (Inch/mm)



SCHEMATICS



PACKAGING

Standard: Magazines

All units oriented with lead #1 to the same side

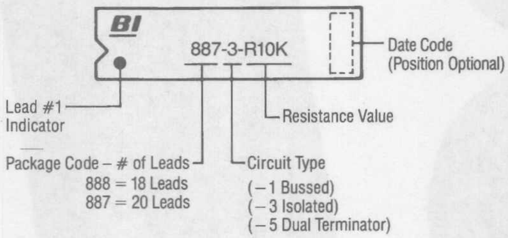
Magazine:	Material	=	Antistatic Plastic
	Capacity	=	20 Units

ORDERING INFORMATION

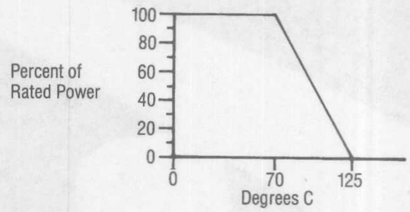
88 7 -5- R220 / 330 F

- 88 — Model Series
- 7 — Number of Leads
  - 8 = 18 Leads
  - 7 = 20 Leads
- -5- — Circuit Type
  - 1 = Bussed
  - 3 = Isolated
  - 5 = Dual Terminator
  - 6 = SCSI Circuit
- R220 — Resistance Value
- 330 — R2 Resistance Value (Add for -5 circuit only)
- F — Accuracy Code (No code used for 2% std.) F = ±1%

TYPICAL PART MARKING

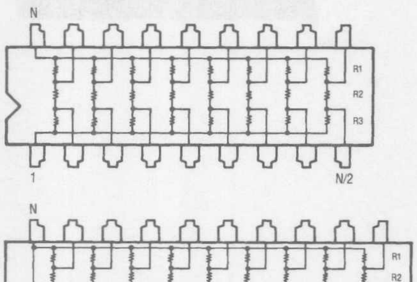


POWER DERATING CURVE



CUSTOM CAPABILITIES

Circuits Shown are representative of our custom circuit capability. Consult factory for additional applications.



POWER DISSIPATION, WATTS AT 70°C

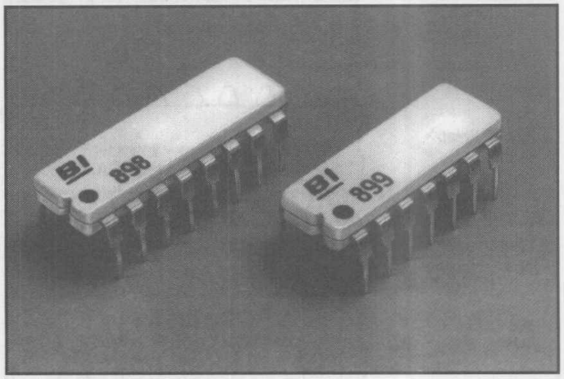
		— Resistor (Per Circuit) —			
Model	Package	-1	-3	-5	-6
887	2.50	.125	.250	.125	.125
888	2.25	.125	.250	.125	.125

MODEL 898, 899

R/2R Ladder

Dual In-Line

Thick Film Resistor Network



ELECTRICAL

Standard Resistance Range, Ohms	10K to 100K
Standard Resistance Tolerance, at 25°C	±2%
Operating Temperature Range	0°C to +70°C
Temperature Coefficient of Resistance	±100ppm/°C
Maximum Operating Voltage	100V dc or √PR
Insulation Resistance	≥10,000 Megohms
Ladder Network Accuracy	8 Bits: ±1/2LSB, 0°C to 70°C
	10 Bits: ±1LSB, 0°C to 70°C

MECHANICAL

Lead Material	Copper Alloy, 60/40 Tin-Lead Plating
Substrate Material	Alumina
Resistor Material	Cermet

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes

Specifications subject to change without notice.

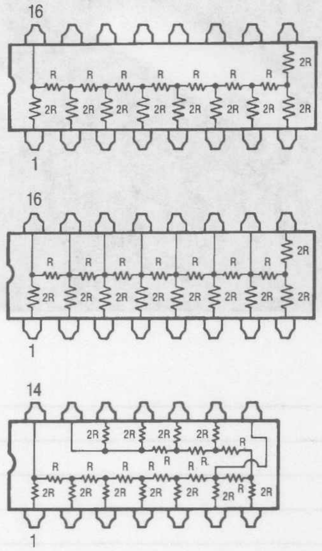
4

SCHEMATICS

898-81 Circuit
(8 Bits)

898-82 Circuit
(8 Bits)

899-10 Circuit
(10 Bits)

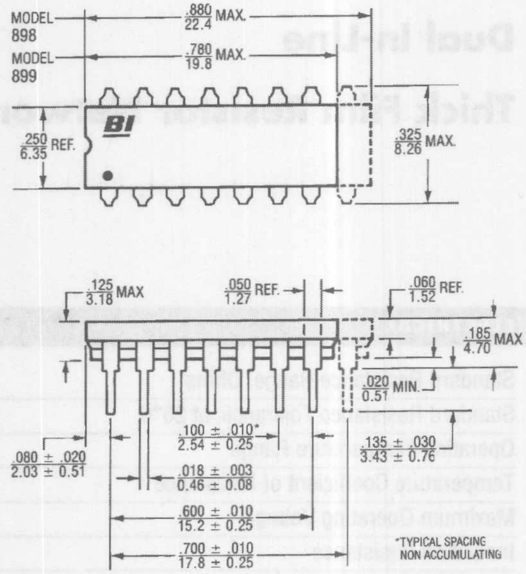


899 = 14 Leads

898 = 16 Leads

Consult factory for custom circuit configurations.

OUTLINE DIMENSIONS (Inch/mm)



STANDARD RESISTANCE VALUES,OHMS

R/2R	R/2R	R/2R
10K/20K	25K/50K	100K/200K
	50K/100K	

POWER DISSIPATION, WATTS AT 70°C

Model	Per Package	Per Resistor
898-8X	0.8	.050
899-10	1.0	.050

ORDERING INFORMATION

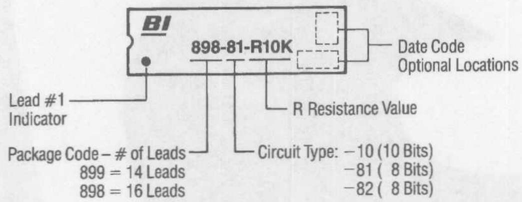
898 -81 R10K

- Model Series — 89
- Number of Leads — 8; 8 = 16 Leads
- Circuit Type — 81; 81 = 8 Bits; 82 = 8 Bits
- R Resistance Value — R10K

899 -10 R10K

- Model Series — 89
- Number of Leads — 9; 9 = 14 Leads
- Circuit Type — 10; 10 = 10 Bits
- R Resistance Value — R10K

TYPICAL PART MARKING



PACKAGING

Standard: Magazines

All units oriented with lead #1 to the same side

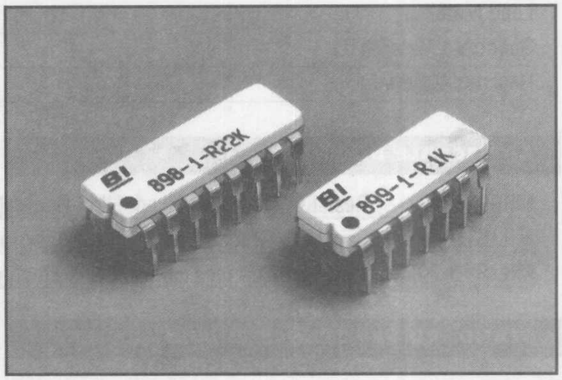
Magazine:	Material	=	Antistatic Plastic
	Capacity	=	25 Units

MODEL 898, 899

Dual In-Line

Thick Film Resistor Network

Distributor Item



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ELECTRICAL

Standard Resistance Range, Ohms	22 to 1Meg
Standard Resistance Tolerance, at 25°C	±2% (<100 Ohms = ±2 Ohms)
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance	±100ppm/°C (<100 Ohms = ±250ppm/°C)
Temperature Coefficient of Resistance Tracking	±50ppm/°C
Maximum Operating Voltage	100V dc or √PR
Insulation Resistance	≥10,000 Megohms

ENVIRONMENTAL (PER MIL-R-83401)

Thermal Shock plus Power Conditioning	ΔR 0.70%
Short Time Overload	ΔR 0.50%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.50%
Mechanical Shock	ΔR 0.25%
Vibration	ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.50%
Load Life, 1,000 Hours	ΔR 1.00%
Resistance to Solder Heat (Per MIL-STD-202, Method 210, Cond.B)	ΔR 0.25%
Dielectric Withstanding Voltage	200V rms for 1 minute
Temperature Exposure, Maximum	215°C for 3 minutes
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL-94V-O Rated
Storage	-55°C to +150°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Copper Alloy, 60/40 Tin-Lead (Plating)
Substrate Material	Alumina
Resistor Material	Cermet

APPLICABLE DOCUMENTS

MIL-R-83401 — Resistor Networks, Fixed, Film, General Specifications

MIL-STD-105 — Sampling Procedures and Tables for Inspection by Attributes

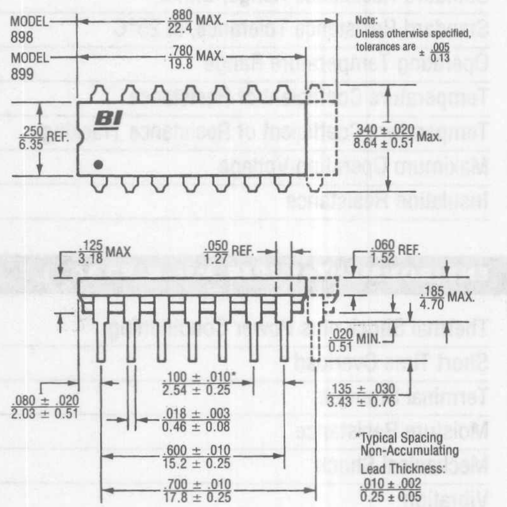
MIL-STD-202 — Test Methods for Electronic and Electrical Component Parts

STANDARD RESISTANCE VALUES, OHMS

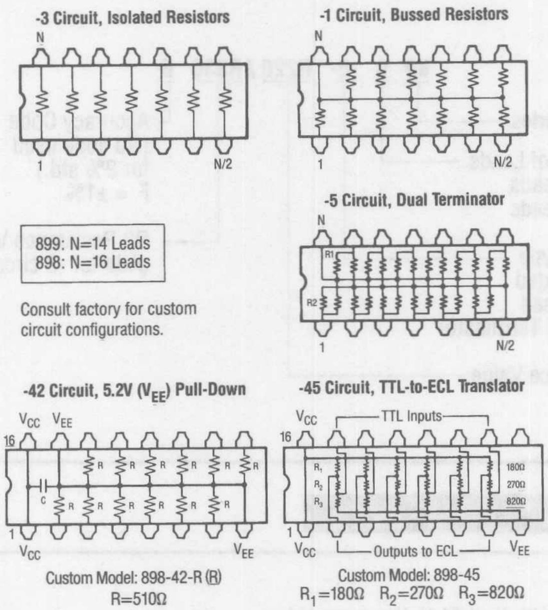
-3 Circuit (Isolated Resistors) & -1 Circuits (Bussed Resistors)			
22	390	5.6K	**100K**
27	470	**6.8K**	120K
33	510	8.2K	150K
39	560	**10K**	180K
47	**680**	12K	200K
51	820	15K	220K
56	**1K**	18K	270K
68	1.2K	20K	330K
82	1.5K	**22K**	390K
100	1.8K	**27K**	470K
120	2K	33K	510K
150	**2.2K**	39K	560K
180	**2.7K**	**47K**	680K
200	3.3K	51K	820K
220	3.9K	56K	**1Meg**
270	**4.7K**	68K	
330	5.1K	82K	
-5 Circuit (Dual Terminators)			
R1/R2	R1/R2	R1/R2	R1/R2
180/390	**220/330**	**330/470**	**3K/6.2K**
220/270	**330/390**	**330/680**	

Resistance values represented in **Bold** face are stock standard values.

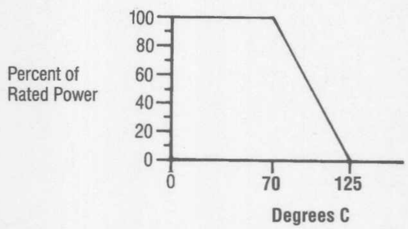
OUTLINE DIMENSIONS (Inch/mm)



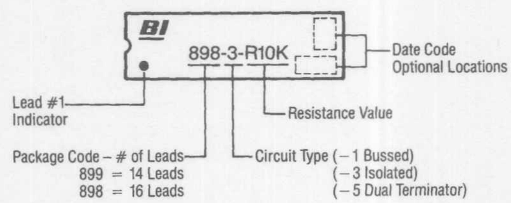
SCHEMATICS



POWER DERATING CURVE



TYPICAL PART MARKING



POWER DISSIPATION, WATTS AT 70°C

		Resistor (Per Circuit)		
Model	Package	-1	-3	-5
898	2.0	.125	.250	.125
899	1.8	.125	.250	.125

ORDERING INFORMATION

89 9 -5- R220 / R330 F

- Model Series — 89
- Number of Leads — 9
  - 9 = 14 Leads
  - 8 = 16 Leads
- Circuit Type — -5-
  - 3 = Isolated
  - 1 = Bussed
  - 5 = Dual Terminator
- Resistance Value — R220
- R2 Resistance Value — R330 (Add for -5 circuit only)
- Accuracy Code — F (No code used for 2% std.)
  - F = ±1%

PACKAGING

Standard: Magazines

All units oriented with lead #1 to the same side

Magazine:			
Magazine:	Material	=	Antistatic Plastic
	Capacity	=	25 Units

CUSTOM NETWORK SPECIFICATION SHEET

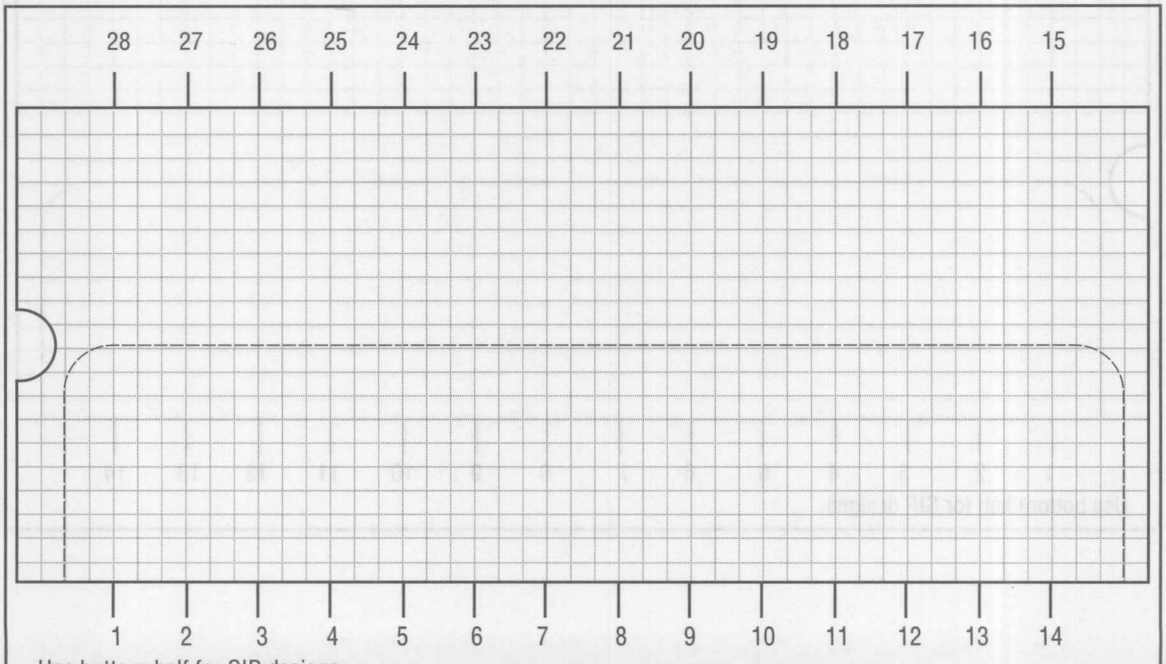
	Pin Count	R.C. Networks Available	Body Style: Through Hole SIP	Body Style: Through Hole DIP	Body Style: SMD .150"	Body Style: SMD .220"	Body Style: SMD .300"
Thick Film	Up to 20 SIP	Yes	◆	◆		◆	
	Up to 20 DIP						
	16 Pin				◆		
Thin Film	8, 14, 16, 18, 20, 24			◆			
	8, 14, 16	No			◆		
	16, 18						◆
Thin Film	3 through 10	No	◆				

In addition to our broad line of standard Thick and Thin Film Resistor Networks, BI specializes in custom resistor and resistor capacitor networks. Application specific components are available if your exact requirements are not met by a standard product.

GUIDELINES FOR SPECIFYING A CUSTOM PRECISION THIN FILM NETWORK:

- Absolute tolerances to $\pm$0.1% are available. For the most cost-effective solution specify the widest tolerances possible: $\pm$0.5% is ideal.
- Ratio matching is available to $\pm$0.01% in hermetic packages and $\pm$0.02% in plastic molded. If possible, specify ratio matches in multiple groups, rather than one large group; yields are better for groups containing only a few ratio matched resistors. Use the lowest value resistor within a group as the reference resistor. Ideal resistance values for accurate ratio matches are in the 1KΩ to 100KΩ range.
- For best results limit total package resistance to less than 3 Megohm for 14 or 16 pin through-hole DIPs and 1 Megohm for 8 pin DIP and surface mount.
- T.C.R. tracking of $\pm$2ppm/°C (+5ppm/°C is standard) is possible for resistors with nearly equal values.

For applications assistance, please call (714) 447-2515.



Use bottom half for SIP designs.

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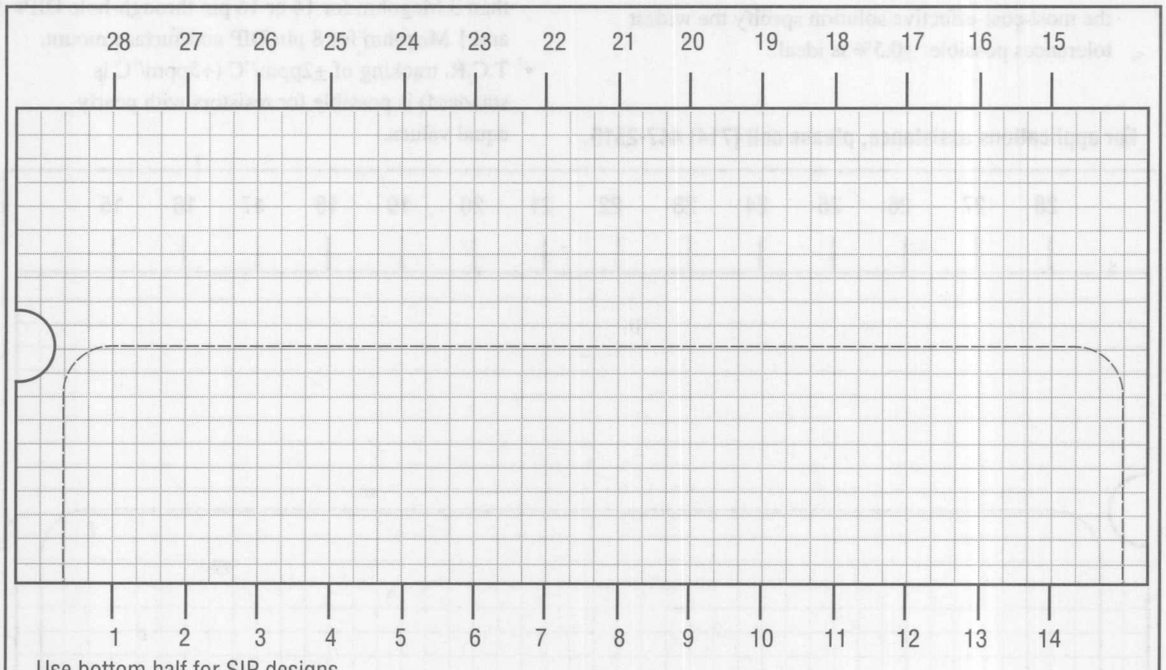
GUIDELINES FOR SPECIFYING A CUSTOM THICK FILM NETWORK (RESISTOR/RESISTOR-CAPACITOR):

- Absolute tolerances to ±0.1%. Don't over specify; ±2% generally provides the most economical solution.
- Ratio matching ±0.1% can usually be achieved for resistors with 5 to 1 or smaller ratios. As with thin film, specify a reference resistor and use groups of small numbers of resistors, rather than one large group with many ratio matches.
- Absolute TCR to ±50ppm/°C.
- TCR tracking to ±15ppm/°C.
- Resistance Range of 20mΩ to 1GΩ plus jumper (0Ω).
- Limit the number of circuit crossovers.

For applications assistance, please call (714) 447-2515.

	Pin Count	R.C. Networks Available	Body Style: Through Hole SIP	Body Style: Through Hole DIP	Body Style: SMD .150"	Body Style: SMD .220"	Body Style: SMD .300"
Thick Film	Up to 20 SIP	Yes	◆	◆		◆	
	Up to 20 DIP						
	16 Pin				◆		
Thin Film	8, 14, 16, 18, 20, 24	No		◆			
	8, 14, 16				◆		
	16, 18						◆
Thin Film	3 through 10	No	◆				

- Avoid buried nodes and loops.
- Capacitors: NPO, X7R, Z5U dielectric; values to 0.1μF depending on voltage. Try to limit the number of capacitors and specify the widest tolerances possible.
- Allow BI to specify pin-out if possible.
- High-volume (to 30kV) also available.
- 50 mil lead pitch SIP package option.



Use bottom half for SIP designs.

CUSTOM NETWORK SPECIFICATION SHEET

Reference Designator	Value	Absolute Tolerance	Ratio Tolerance	TCR Tracking	Reference Resistor	Power
R1						
R2						
R3						
R4						
R5						
R6						
R7						
R8						
R9						
R10						
R11						
R12						
R13						
R14						
R15						

Absolute TCR: ____________

	Value	Rated Voltage	Dielectric	Tolerance		
C1						
C2						
C3						
C4						
C5						

Name/Title ________________________________

Company Name ________________________________

Address ________________________________

____

Phone (   ) ____________ Extension ____________ FAX (   ) ____________

Application Notes
Passive Networks

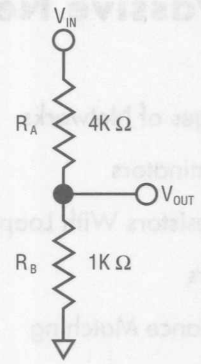
NETWORK PRODUCTS

THE NETWORK ADVANTAGE

Resistor networks offer distinct advantages over discrete resistors.

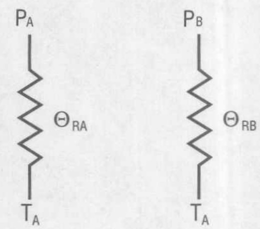
Board space Savings. In applications such as terminators where lead routing is straightforward, both DIPs and SIPs can reduce board real estate requirements.

Improved Temperature Tracking. Significantly improved temperature tracking between resistors occurs in three ways. Consider the voltage divider and thermal models shown:

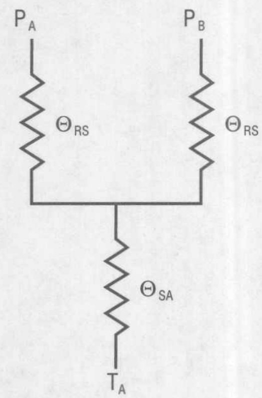


$$V_{OUT} = V_{IN}\left(\frac{R_B}{R_A + R_B}\right) = \frac{V_{IN}}{5}$$

The thermal model for the discrete resistors shows that each resistor rises above ambient independently. In the voltage divider example, the power dissipation in R_A is 4 times the power dissipation in R_B. Assuming that each discrete resistor's thermal resistance to ambient is about the same, the difference in temperature rise will be 4:1. Depending on the values of V_{IN} and R_A and R_B, this could result in a severe temperature tracking problem.



Thermal Model for Discrete Resistors



Thermal Model for a Network

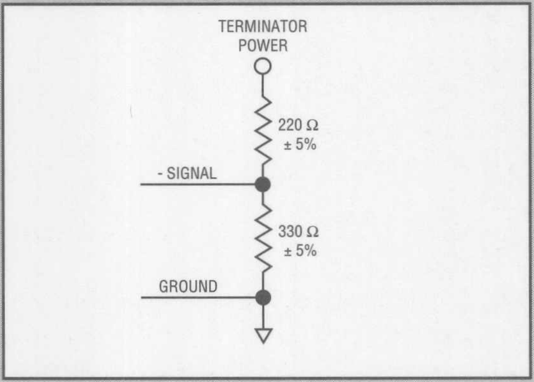
Using a network, the temperature tracking problem is improved in three ways:

1. The thermal resistance of each resistor to the substrate is very low since the alumina substrate and the resistor materials have excellent thermal conductivity compared to air. This means that the temperature rise of each resistor above the substrate will be very low and the individual resistors will track much better, even with unequal power dissipations.
2. The resistors located on a single substrate will no longer be subject to the independent influence of cooling air, board hot spots, and convection currents. The large thermal resistance from substrate to air is virtually identical for both resistors.
3. Temperature tracking is not a function of absolute TCR.

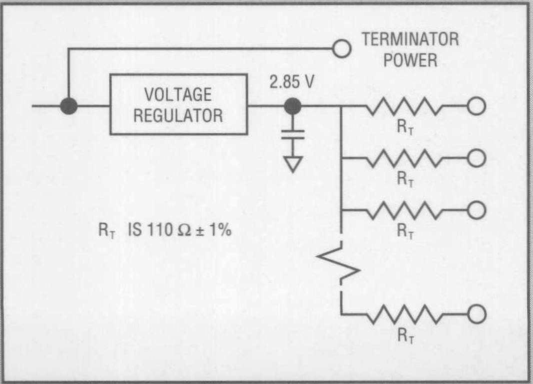
SCSI BUS TERMINATION NETWORKS

The Small Computer System Interface (SCSI) standards were developed by the American National Standards Institute (ANSI) to establish the mechanical, electrical, and functional requirements for interconnecting small computers and their peripherals. The SCSI bus is a local I/O bus operated over a wide range of data rates. The purpose of the bus is to permit the interconnection of devices without requiring hardware or software changes. When interconnecting devices on the bus, both ends of each cable must be terminated. Both single ended and differential configurations are permitted.

SINGLE ENDED TERMINATIONS



Option 1



Option 2

BI Technologies manufactures networks specifically designed to provide SCSI bus termination. Send for BI's special application sheet "Resistor Network Applications in SCSI Bus Systems."

The following BI resistor network package alternatives are available.

SINGLE ENDED "A" CABLE, 18 LINE TERMINATIONS

Option 1 Terminations

Quantity Required	Package Style	Part Number
1 each	20 Pin DIP	887-5-R220/R330
2 each	11 Pin SIP	L11-5C-221/331
3 each	8 Pin SIP	L08-5C-221/331

Option 2 Terminations

Quantity Required	Package Style	Part Number
1 each	20 Pin DIP	887-1-R110F
2 each	10 Pin SIP	L10-1C-111F

SINGLE ENDED "B" CABLE, 29 LINE TERMINATIONS

Option 1 Terminations

Quantity Required	Package Style	Part Number
2 each	18 Pin DIP	885-5-R220/R330
3 each	12 Pin SIP	L12-5C-221/331
4 each	10 Pin SIP	L10-5C-221/331

Option 2 Terminations

Quantity Required	Package Style	Part Number
2 each	16 Pin DIP	898-1-R110F
3 each	11 Pin SIP	L11-1C-111F

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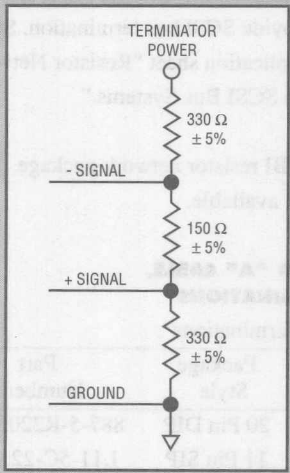
DIFFERENTIAL TERMINATIONS



DIFFERENTIAL "A" CABLE, 36 LINE TERMINATIONS

Quantity Required	Package Style	Part Number
2 each	20 Pin DIP	887-6-R330/R150
3 each	14 Pin SIP	L14 Special
5 each	10 Pin SIP	L10 Special

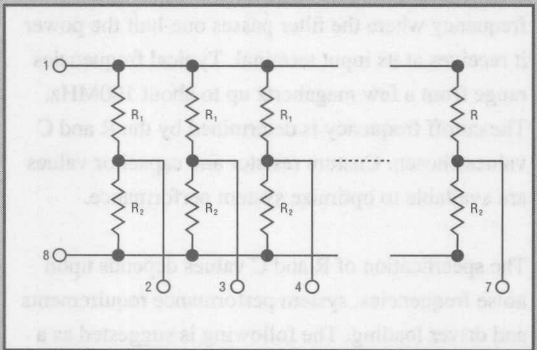
DIFFERENTIAL "B" CABLE, 58 LINE TERMINATIONS

Quantity Required	Package Style	Part Number
4 each	18 Pin DIP	888-6-R330/R150
5 each	14 Pin SIP	L14 Special
8 each	10 Pin SIP	L10 Special

MEASURING NETWORKS WITH LOOPS

There are many kinds of circuits where a certain resistor in a network may be bridged by a loop of other resistors. Some examples from the linear circuit world are bridges and attenuator pads. It is not always desirable or possible to break the loop in a resistor network where pins may be very limited.

A good example of a very common digital network containing circuit loops is the dual terminator network shown in the drawing below. In this network there is a series-parallel circuit that interferes with the accurate measurement of any single resistor.



In a network with loops, the initial adjustment to tolerance and subsequent test and inspection steps may be accomplished accurately by the use of a guarded ohmmeter or guarded precision bridge. The guard electronically removes the parallel paths or loops by applying a voltage to the loop network in such a manner that the loop current is essentially zero.

In the example above, the resistor at the far left labeled R2 may be accurately measured by connecting the ohmmeter or bridge from pin 8 to pin 2 and connecting the guard to pin 1. The guard will drive pin 1 so that the voltage across R1 is essentially zero and no loop current flows through R2, the resistor being measured. Using this method each resistor in the network may be precisely measured.

The guard method will work as long as the guarded ohmmeter or bridge can supply the necessary current to drive the loop network. As a practical matter, large ratios of a single resistor to the parallel network will reduce accuracy. Another situation that should be avoided is the use of resistors small enough that the resistance of the cermet conductors on the substrate will interfere with accuracy. When tight temperature tracking or tight TCR is required in resistors of 500 ohms or less, it is recommended that you contact the factory for applications assistance.

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EMI/RFI FILTERS

GENERAL DESCRIPTION

EMI/RFI low pass filters are used in computers, data terminals, test equipment and process controllers to suppress high frequency noise coming into or exiting electronic equipment.

LOW-PASS FILTER NETWORKS FOR EMI/RFI SUPPRESSION

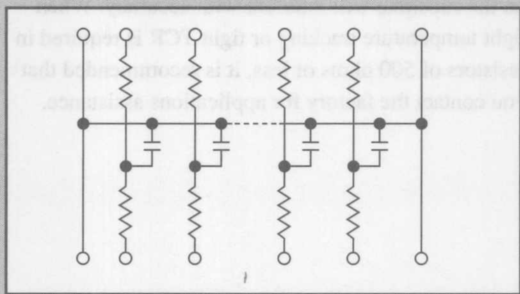


FIGURE 1. RC filter network

BI Technologies supplies a variety of customized RC networks in through hole DIP, SIP and surface mount packages. Included in this section is a discussion of filter theory and FCC regulations.

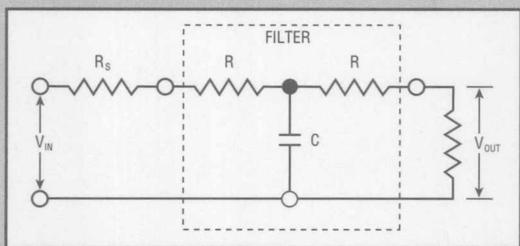


FIGURE 2. Filter configuration

Under steady state conditions, capacitor C blocks the DC component of the input waveform. The DC component of the signal voltage is passed to the load reduced in value by the voltage drop across the two series resistors, R.

Noise is attenuated by a voltage divider consisting of the first resistor R and C. Ideally, for high frequencies, little or no noise reaches the load. Input noise, therefore, will minimally affect the desired signal voltages at the load.

Symmetrical filter design means operation is the same for waveforms traveling in the opposite direction. Such a symmetrical design is useful for filtering signals on a bidirectional bus.

FILTER DESIGN CONSIDERATIONS

R_S = Source Resistance
R_L = Load Resistance
R = Resistance of filter
C = Capacitance of filter

The filter cutoff frequency, f_C, is defined as the frequency where the filter passes one-half the power it receives at its input terminal. Typical frequencies range from a few megahertz up to about 100MHz. The cutoff frequency is determined by the R and C values chosen. Custom resistor and capacitor values are available to optimize system performance.

The specification of R and C values depends upon noise frequencies, system performance requirements and driver loading. The following is suggested as a starting point for approximate values of R and C. Exact values are usually determined by breadboarding.

First choose the desired cutoff frequency, f_C, of the filter. f_C should be selected to pass the signal frequency and reject the dominant frequencies of the EMI/RFI noise.

The transfer function for the filter shown in figure 2 is given in equation 1.

$$\frac{V_{OUT}}{V_{IN}} = \frac{R_L}{j\omega C(R + R_S)(R + R_L) + (R_S + R_L + 2R)}$$

EQUATION 1.

The pole of the filter is determined by setting the denominator of the transfer function equal to zero. The cutoff frequency is given in equation 2.

$$f_C = \frac{R_S + R_L + 2R}{2\pi C(R + R_S)(R + R_L)}$$

EQUATION 2.

Ensure that the additional RC time constant will not cause the signal to violate any input restrictions of the receiving IC.

The rise time from 10% to 90% amplitude can be calculated with equations 3 and 4.

$$t_{10-90} = 2.2\, R_{th}C$$

$$t_{10-90} = 2.2\, \frac{(R + R_S)(R + R_L)}{R_S + R_L + 2R}\, C$$

EQUATIONS 3 AND 4

Where R_{th} is the Thevenin equivalent resistance seen by the capacitor.

Minimize the insertion loss by choosing small R values relative to the load impedance. Typical values for R range from 10 to 50 ohms.

EMI/RFI LIMITS

The maximum radiation of electromagnetic interference and radio frequency interference (EMI/RFI) to the environment is limited by regulations in most developed countries. According to FCC regulations (Parts 15 and 18), emissions must not exceed certain maximum levels. The levels depend on whether the equipment is for industrial use or for residential use. A graphical representation of these limits is shown in Figure 3.

Similar restrictions apply to equipment sold in Europe (VDE 0871, a German standard), Japan (VCCI) and to the military (MIL-STD-461/462).

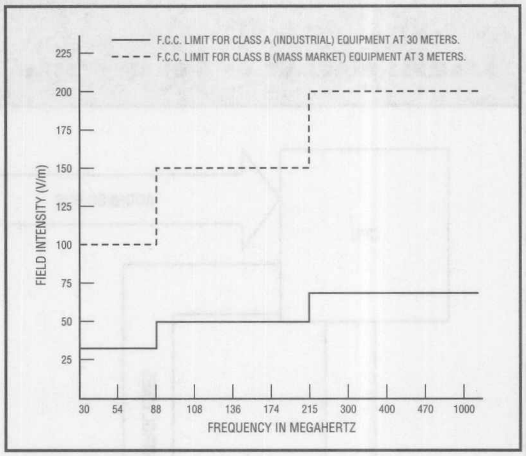


FIGURE 3. FCC radiation limits for class A and class B computing devices

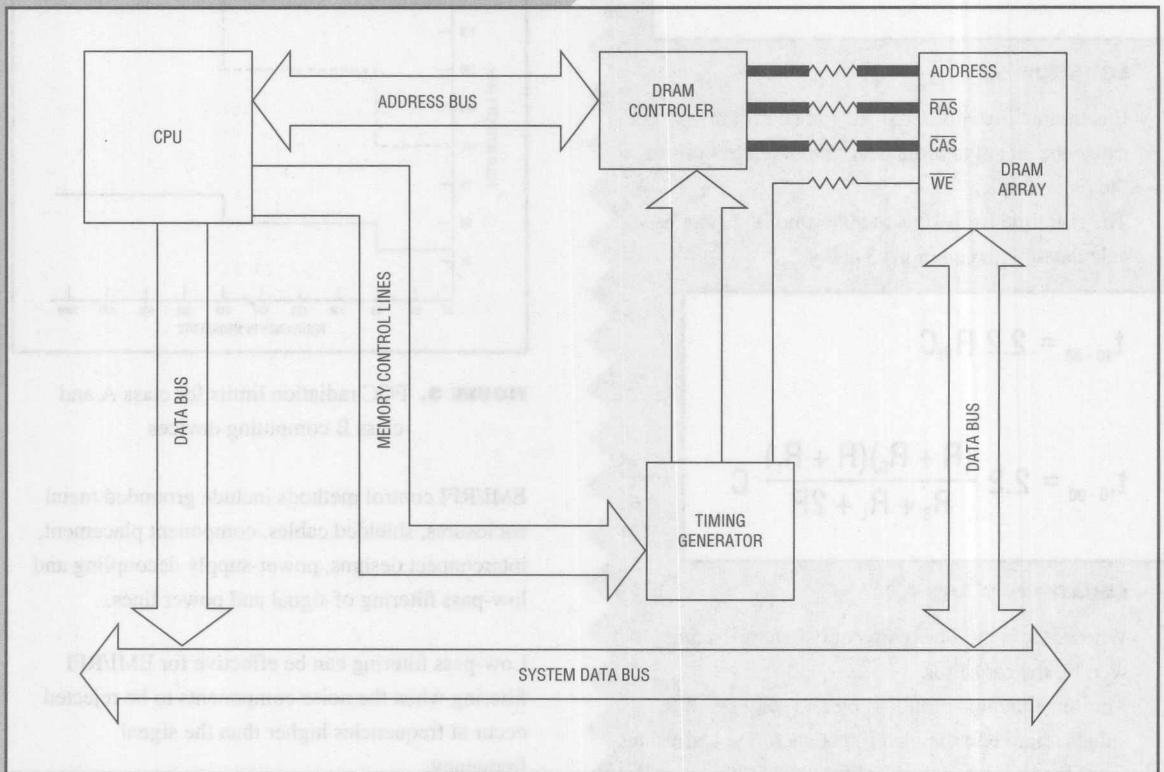
EMI/RFI control methods include grounded metal enclosures, shielded cables, component placement, interconnect designs, power-supply decoupling and low-pass filtering of signal and power lines.

Low-pass filtering can be effective for EMI/RFI filtering when the noise components to be rejected occur at frequencies higher than the signal frequency.

A typical application would be to filter signal lines between RS-232 drivers and their corresponding connectors. In such low to medium frequency applications, these networks represent a more useful (and economical) solution than inductive type filters such as ferrite beads. In fact, ferrite beads become mostly ineffective below 10MHz.

NETWORKS IN DRAM APPLICATIONS

EXAMPLE DIAGRAM OF A DRAM SYSTEM



USE BI-RESISTOR NETWORKS TO:

- Match impedance between the memory driver and the DRAM array.
- Minimize reflections and ringing in DRAM inputs.
- Prevent undershoot of RAS, CAS, and WE signals, that could cause latch-up of DRAM inputs.
- Improve system performance by allowing faster settling times for DRAM inputs.

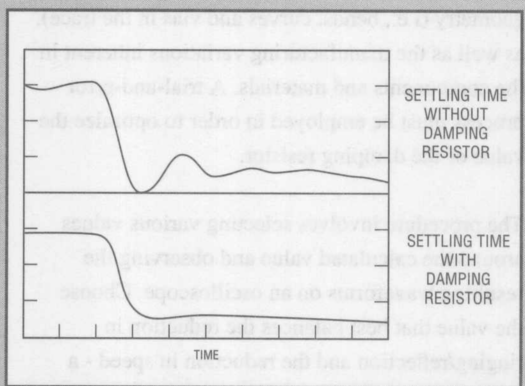
NEED FOR DAMPING

The address lines ($\overline{RAS}$, $\overline{CAS}$) and control lines ($\overline{WE}$) of dynamic RAM arrays are driven in parallel. This causes significant loading on the driver of the DRAM arrays. Each DRAM control input ($\overline{WE}$) has capacitive loading between 5pF to 7pF, while each address line input has about a 10pF load.

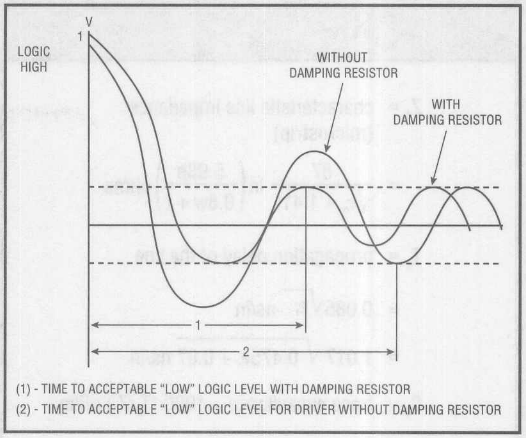
Each DRAM input can therefore be modeled as a transmission line with distributed inductance and capacitance. If not properly terminated, signal reflections and ringing on the line will result, adversely affecting the performance of the memory system. The effects on signal transitions will be:

1. Increased settling time delay on low-to-high transitions.
2. Voltage undershoot on high-to-low transitions.

EFFECT OF DAMPING ON ADDRESS AND CONTROL LINES



Increased settling time due to ringing reduces the system performance because the design has to allow for the settling delay before latching data. Undershoot, by bringing the input voltage below 0 volts, can damage the driver IC as well as alter the DRAM's internal address register contents, causing data errors.



APPLICATION GUIDELINES

Termination of address and control lines is typically accomplished with low-valued resistors placed in series at the driver output. Selection of the proper resistance value is performed in two steps:

1. Approximation of the proper resistance using transmission line equations.

2. Breadboarding and changing the resistance value to account for real world deviations such as PCB vias and bends.

Z_0 = characteristic line impedance (microstrip)

$$= \frac{87}{\sqrt{\varepsilon_r + 1.41}} \ln\left(\frac{5.98h}{0.8w + t}\right) \text{ohms}$$

T_d = propagation delay of the line

$$= 0.085\sqrt{\varepsilon_r} \text{ ns/in}$$

$$= 1.017\sqrt{0.475\varepsilon_r + 0.67} \text{ ns/in.}$$

C_0 = trace capacitance = $1000\,(T_d/Z_0)$ pF/in.

C_d = equivalent trace capacitance per DRAM line.

= 7 pF/in.

Z_0' = effective characteristic impedance, including DRAM capacitive loading

$$= \frac{Z_0}{\sqrt{1 + C_d/C_0}}$$

T_d' = effective propagation delay

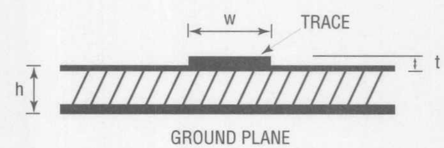
$$T_d = T_d\sqrt{1 + C_d/C_0}$$

where ε_r = relative dielectric constant of the substrate

h = distance from the trace to the ground plane

w = width of trace

t = thickness of trace



The applicable transmission line equations are:

For example, for a trace with the following characteristics:

ε_r = 5 (for G10 glass epoxy)
h = 0.060 inch
w = 0.010 inch
t = 0.003 inch

then, Zo = 120 ohms
Td = 0.19 ns/in.
Co = 1.58 pF/in.
Zo = 51 ohms
Td = 0.44 ns/in.

A theoretical resistance of 51 ohms will match the trace impedance of the PCB.

The necessary resistance will differ from this value due to non-ideal characteristics of the PCB trace geometry (i.e., bends, curves and vias in the trace), as well as the manufacturing variations inherent in the components and materials. A trial-and-error process must be employed in order to optimize the value of the damping resistor.

The procedure involves selecting various values around the calculated value and observing the resulting waveforms on an oscilloscope. Choose the value that best balances the reduction in ringing/reflection and the reduction in speed - a large resistance value provides better damping, but will also add delay by slowing the edge rate. Typically, resistance values for memory damping will be in the range of 10 ohms to 50 ohms, with the most common values in the 20 ohm to 30 ohm range.

Since memory damping is a type of series termination, distributed loading along the line will not be possible. That is, the entire lumped load must be located at the end of the line, with no other loads along the signal path. This will guarantee that the waveform will remain undisturbed as it travels along the line. For related reasons, the placement of the series damping resistor should be as close to the driving device as possible.

BI NETWORKS FOR MEMORY DAMPING

BI can supply a wide range of resistor networks for memory damping applications. Standard resistance values are normally in stock. Any value within the range of 22 ohms to 1 megohm can be supplied.

The following BI Network products make excellent choices for memory damping applications.

- Through hole DIP packages
  898 or 899 Series
- Through hole SIP packages
  BH or BL Series
- Surface mount packages
  Models 627A or 628A small outline DIP
- Model BCN

All models above are available in standard resistance values from 22 ohms to 1 megohm.

AC TERMINATION

WHEN TO TERMINATE TRANSMISSION LINES

A transmission line should be terminated if the length of the line, or trace, satisfies the inequality

$$L > \frac{T_r}{2\,T_d}$$

L is the length of the transmission line, T_r is the signal rise time at the source and T_d is the propagation delay per unit length of the transmission line.

The typical propagation delay for common trace widths and PCB materials is approximately 1.7 nsec per foot. For a rise time of 2 nsec, the critical length determined from the above inequality is:

$$L = \frac{2\text{nsec.}}{2 \times 1.7\ \text{nsec/ft.}}$$
$$= 0.59\ \text{ft.}$$
$$= 7\ \text{in.}$$

In other words, line lengths greater than or equal to 7 inches should be terminated. Line terminations are needed for clock inputs, read/write strobe lines on SRAM's and chip select and output enable lines on PLD, PROM and RAM devices. Terminations are not needed on address and data lines since they generally operate at lower speeds.

WHERE TO TERMINATE TRANSMISSION LINES

The termination should be applied at the load which is electrically farthest from the source. This load is usually located at the farthest physical distance from the source.

PARALLEL AC TERMINATION

The Parallel AC Termination network is a general purpose termination that is preferred over a simple series or parallel termination. An example of the Parallel AC Termination is shown in Figure 1.

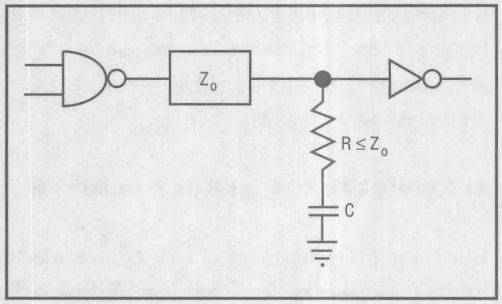


FIGURE 1. Parallel AC Termination

WHY AN AC TERMINATION

- Prevents DC power loss since DC current is blocked by a capacitor.
- Does not produce level shift in the output high voltage, V_{OH}, or output low voltage, V_{OL}.
- Attenuates high frequency AC noise peaks to levels less than the signal.

PARALLEL AC TERMINATION'S FUNCTION AS A LOW PASS FILTER

The Parallel AC Termination also serves the secondary role as a low pass filter. This is demonstrated by evaluating the negative and the positive step functions of the circuit shown in Figure 2.
To evaluate the negative step function response, the switch in Figure 2 is toggled from the ON position to OFF after the circuit has reached its steady state in the ON position at t=0. At time $t=0^+$, the voltge across the capacitor, $V_c(t)$ is equal to V. $V_c(t)$ is then given by:

$$V_c(t) = Ve^{-t/(R2+R3)C} \qquad (1)$$

In evaluating the positive step function response, the switch in Figure 2 is flipped from the OFF position to ON at t=0. The voltage across the capacitor $V_c(t)$ is expressed as:

$$V_c(t) = V[1-e^{-t/(R1+R3)C}] \qquad (2)$$

In theory, $V_c(t)$ reaches V in the positive step response when t equals infinity. In the practical case, $V_c(t)$ reaches 0.98 of V after 3.9 time constants, RC. Likewise, in the negative step response $V_c(t)$ reaches 0.02 of V after 3.9 time constants

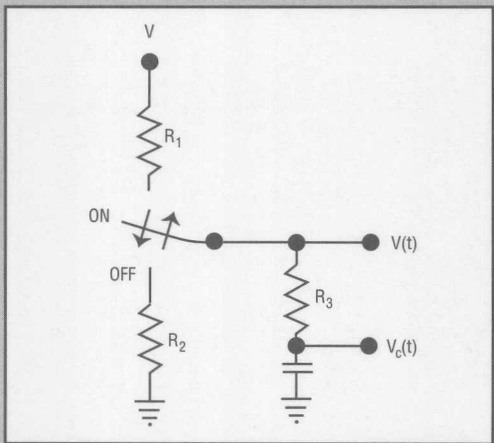


FIGURE 2. AC Termination: Low Pass Filter Model

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CALCULATING THE CAPACITANCE OF THE PARALLEL AC TERMINATION

The Ideal Case

The parallel AC Termination is designed with a capacitance, C, which is large enough to filter positive (rising) and negative (falling) glitches. In addition, it is designed not to be so large as to cause any signal delay beyond the design threshold or to increase signal rise and fall times to be greater than 5 nsec. In short, the value of the capacitance is limited by maximum and minimum values.

For R1=0, equation (2) becomes:

$$V_c(t) = V[1-e^{-t/RC}] \qquad (3)$$

where R = R3.

From equation (3) the time, T, required for the signal to rise from 10% to 90% of the full amplitude is calculated as:

$$T = 2.2RC \qquad (4)$$

Solving for capacitance gives:

$$C = \frac{T}{2.2R} \qquad (5)$$

For a line impedance of 50Ω, the value chosen for R is 47Ω since $R \le Z_O$ (see Figure 1) and 47Ω is a standard value. Substituting 5 nsec and 47Ω into equation (5),

$$C = 48 \text{ pF}$$

Since positive and negative pulses of width T will be eliminated if T<4RC, a glitch of width 9 nsec or less will not be passed by the filter.

The Real World

In reality, the values R1 and R2 in Figure 2 need to be taken into consideration. These resistance values are determined from the data sheets of the components connected to the trace or line. R1 is added to R3, in this case 47Ω, to find R. The capacitance, C, is then calculated from equation (5). The time constant, RC, must not violate the line's minimum pulse width criteria of the design. Use a smaller C if the minimum pulse width criteria is violated. R2 is also added to R3, again 47Ω in this case, to find R. C is again calculated from equation

(5). If RC violates the line's minimum negative pulse width criteria, reduce the capacitance.

WHY USE BI TECHNOLOGIES RC NETWORKS FOR AC TERMINATIONS

- Provide improved reliability over discrete RC networks.
- Real estate savings of 50% compared to discrete components.
- Pick and place cost saving of 50% compared to discrete RC networks.
- Increased board yields due to component count reduction.
- Reduced PCB trace routing problems.
- Minimized PCB trace inductance with RC chips.
- RC chips permit placement very close to active devices.

WHICH BI TECHNOLOGIES RC NETWORKS TO USE FOR AC TERMINATIONS

- Model RC 3 / RC 4
- Model RC 6 circuit types B, C and E

SOLDERING PROCEDURES FOR BI TECHNOLOGIES FIXED FILM PRODUCTS

WAVE SOLDERING

Preheating is performed by increasing the temperature of the components and PCB (or substrate) at a rate between 1.5°C/sec. and 2.5°C/sec. until at least 150°C is reached. That is, until a temperature within 100°C of the soldering temperature of 250°C is achieved. The duration of preheating should be at least 60 sec. and not exceed 90 sec. Soldering should last no longer than 5 sec. at 250°C, and soldered parts are cooled in still air. This procedure is shown graphically in Figure 1.

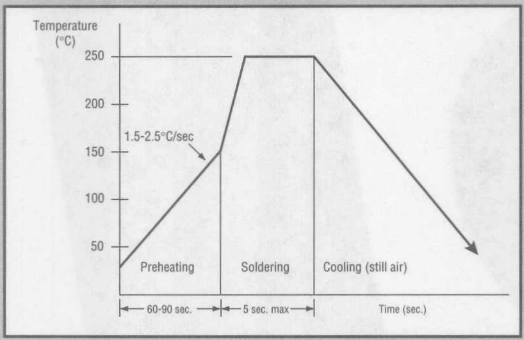


FIGURE 1. Wave Soldering

IR REFLOW SOLDERING

During preheating, increase the temperature of the parts at the rate of 3°C/sec. to attain the final preheat temperature of 150°C. The total time required to raise the temperature to 150°C should not exceed 45 sec. The total time required for achieving and maintaining the temperature at 150°C should not exceed 90 sec. Increase the temperature from 150°C to the final soldering temperature of 240°C at the rate of 4°C/sec. Total soldering time should last 30 sec., and soldered parts are allowed to cool in still air. As shown graphically in Figure 2.

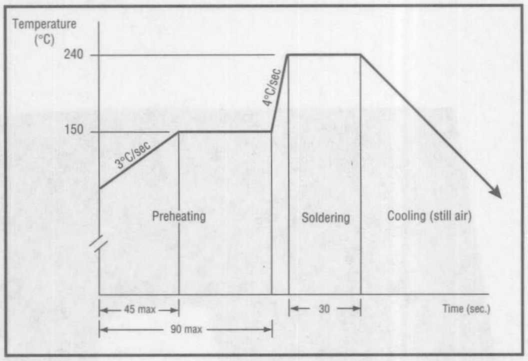


FIGURE 2. IR Reflow Soldering

CONVECTION REFLOW SOLDERING

Similar to that of wave soldering, preheating is performed by increasing the temperature of the components and board at a rate between 1.5°C/sec. and 2.5°C/sec. until at least 130°C is reached. That is, until a temperature within 100°C of the soldering temperature of 230°C is achieved. The duration of preheating should be at least 60 sec. and not exceed 90 sec. Soldering should last no longer than 5 sec. at 230°C. After completed, soldered parts are cooled in still air. This is graphically represented in Figure 3.

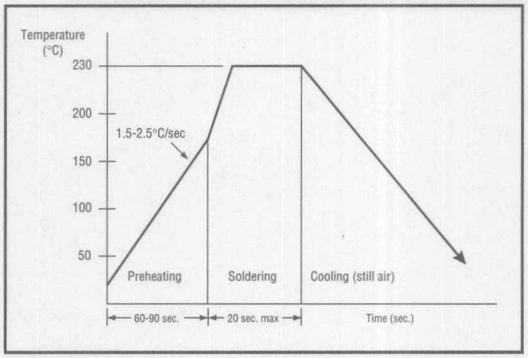


FIGURE 3. Convection Reflow Soldering

4

Discrete Components

Chip Resistors
Power Resistors

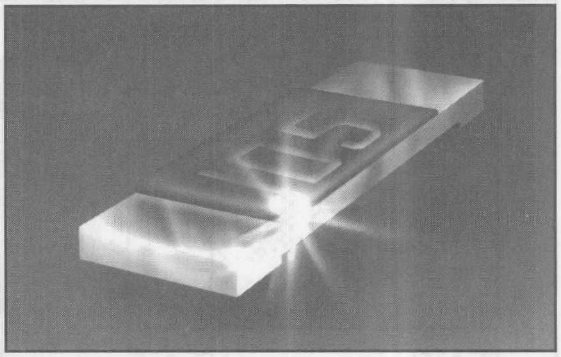
5

BCR SERIES

Thick Film

Chip Resistors

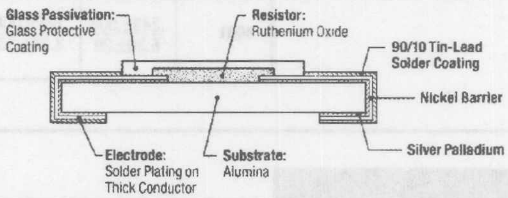
Distributor Item



OUTSTANDING FEATURES

- **Seven Styles/Six Power Ratings Available** - Including the popular 0805 and 1206 versions
- **±0.5% Tolerance offered** - Low cost solution to precision requirements
- **Tight Dimensional Tolerances** - Ensure reliable high yield board assembly
- **Nickel Barrier Terminations** - For long term solder joint reliability
- **Glass Passivation** - Provides superior environmental protection
- **Ruthenium Oxide Thick Film** - Chosen for accurate and stable resistors
- **Jumper Chip is Standard** - Provides <50 milliohm short

CONSTRUCTION



ELECTRICAL

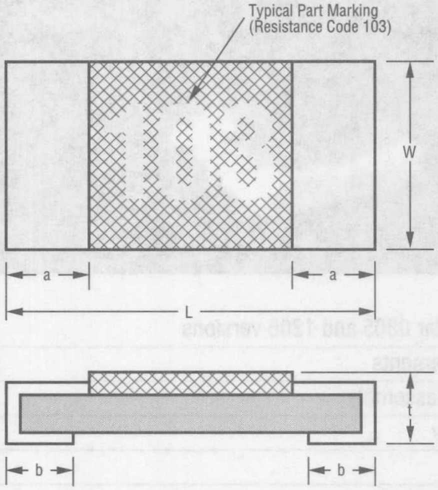
Model	BCR1/32	BCR1/16	BCR1/10	BCR1/8	BCR1/4	BCR1/2	BCR 1
Industry Style, Inch (mm)	0402 (1050)	0603 (1608)	0805 (2012)	1206 (3216)	1210 (3225)	2010 (5025)	2512 (6332)
Standard Resistance Tolerances	±1% (**F Tol.**) ±5% (**J Tol.**)	±1% (**F Tol.**) ±5% (**J Tol.**)	±.5% (**D Tol.**) ±1% (**F Tol.**) ±5% (**J Tol.**)		±1% (**F Tol.**) ±5% (**J Tol.**)		
Standard Resistance Range, Ohms	10Ω to1MegΩ F Tol.- E96 J Tol.- E24	10 Ohms to 1 Megohm (Plus "Zero Ohm" Jumper Chip), J Tol. - E24 • F Tol. - E96 51 Ohms to 510K Ohms, D Tol. - E96					
Operating Temperature Range	-55°C to +125°C						
Power Rating, Watts*	0.063 at 70°C		0.125 at 70°C	0.250 at 70°C	0.250 at 70°C	0.500 at 70°C	1.0 at 70°C
Rated Current/Peak Current, Amps**	1A/2A		1.5A/3A	2A/4A			
Temperature Coefficient of Resistance	±200ppm/°C (F & J Tol.)		±100ppm/°C (D & F Tol.) ±200ppm/°C (J Tol.)		±100ppm/°C (F Tol.) ±200ppm/°C (J Tol.)		
Operating Voltage, Max./ Overload Voltage, Max.	50/100Vdc		150/300Vdc		200/400Vdc		

* Not to exceed Maximum Operating Voltage. Derates to 0 at 125°C.

** Also applies to Jumper Chips

Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)

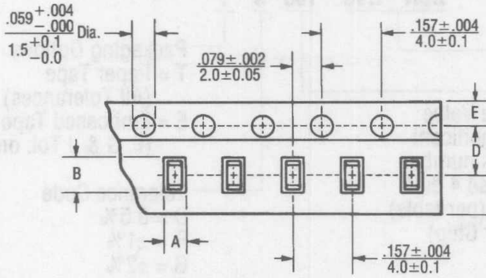


Model	L	W	t	a	b
BCR1/32	.039±.002 1.00±.05	$.020^{+.004}_{-.002}$ $.50^{+.10}_{-.05}$	.014±.002 .35±.05	.008±.004 .20±.10	$.01^{+.002}_{-.004}$ $.25^{+.05}_{-.10}$
BCR1/16	.063±.006 1.60±.15	.031±.006 .80±.15	.018±.004 .45±0.10	.012±.008 .30±.20	.012±.008 .30±.20
BCR1/10	.079±.008 2.0±.20	.049±.004 1.25±.10	.020±.004 .50±.10	.016±.008 .40±.20	.016±.008 .40±.20
BCR1/8	$.126^{+.002}_{-.008}$ $3.20^{+.05}_{-.20}$	$.063^{+.002}_{-.006}$ $1.60^{+.05}_{-.15}$	.024±.004 0.60±.10	.020±.01 .50±.25	.020±.012 .50±.30
BCR1/4	.126±.008 3.20±.20	$.098^{+.008}_{-.004}$ $2.50^{+.20}_{-.10}$	.024±.004 .60±.10	.020±.008 .50±.20	.020±.008 .50±.20
BCR1/2	.197±.008 5.0±.20	.098±.006 2.5±.15	.024±.004 .60±.10	.024±.004 .60±.20	.020±.012 .50±.30
BCR1	.248±.008 6.30±.20	.126±.008 3.20±.20	.023±.004 .60±.10	.028±.008 .70±.20	.028±.008 .70±.20

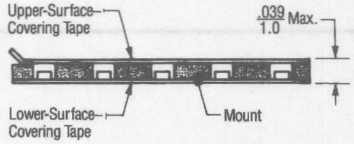
RESISTANCE CODE TABLE

Resistance (Ohm)	G (2%) and J (5%) Tolerance	F (1%) and D (0.5%) Tolerance
0	JP	–
1-9	All digits significant	–
10-99	Two digits significant, third digit multiplier	All digits significant
100-1Meg	Two digits significant, third digit multiplier	Three digits significant, fourth digit multiplier
Example		
2 Ohm	2R0 "R" denotes decimal place	–
20 Ohm	200	20R0 "R" denotes decimal place
20K Ohm	203	2002

Paper and Embossed Tape



Paper Tape



Embossed Tape

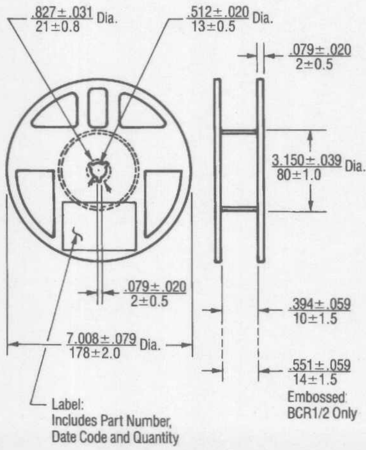
Paper Tape

Dim.	BCR1/32	BCR1/16	BCR1/10	BCR1/8
A	.026±.004 .65±0.1	.043±.008 1.1±0.2	.065±.008 1.65±0.2	.079±.008 2.0±0.2
B	.045±.004 1.15±0.1	.075±.008 1.9±0.2	.094±.008 2.4±0.2	.142±.008 3.6±0.2
C	.315±.008 8.0±0.2			
D	.138±.002 3.5±0.05			
E	.069±.002 1.75±0.05			

Embossed Tape

Dim.	BCR1/4	BCR1/2	BCR1
A	.110±.008 2.8±0.2		.138±.004 3.5±0.1
B	.138±.008 3.5±0.2	.209±.008 5.3±0.2	.266±.004 6.75±0.1
C	.315±.012 8.0±0.3	.472±.012 12.0±0.3	.472±.008 12.0±0.2
D	.138±.008 3.5±0.2	.217±.002 5.5±0.05	
E	.069±.004 1.75±0.10		

Reel



7" Reel Capacity				13" Reel Capacity			
Industry Style	Model Number	Paper Tape	Embossed Tape	Industry Style	Model Number	Paper Tape	Embossed Tape
0402	BCR1/32	10K pcs/reel	—	0602	BCR1/32	20K pcs/reel	—
0603	BCR1/16	5K pcs/reel	—	0603	BCR1/16	20K pcs/reel	—
0805	BCR1/10	5K pcs/reel	—	0805	BCR1/10	20K pcs/reel	—
1206	BCR1/8	5K pcs/reel	—	1206	BCR1/8	20K pcs/reel	—
1210	BCR1/4	—	4K pcs/reel	1210	BCR1/4	—	16K pcs/reel
2010	BCR1/2	—	4K pcs/reel	2010	BCR1/2	—	16K pcs/reel
2512	BCR1	—	4K pcs/reel	2512	BCR1	—	16K pcs/reel

ORDERING INFORMATION

BCR 1/10 103 J T

Model Series — BCR

Resistance Code — 103
Nominal Resistance Value
First 2 digits are significant
Third digit indicates number of trailing zeros. Use 4 digit code on F & D Tol. (per table)
(Use JP for Jumper Chip)

Tolerance Code — J
D = 0.5%
F = ±1%
G = ±2%
J = ±5%
(For Jumper Chip; e.g. BCR 1/10 JPT)

Packaging Options — T
T = Paper Tape
(All Tolerances)
E = Embossed Tape
(F, G & J Tol. only)

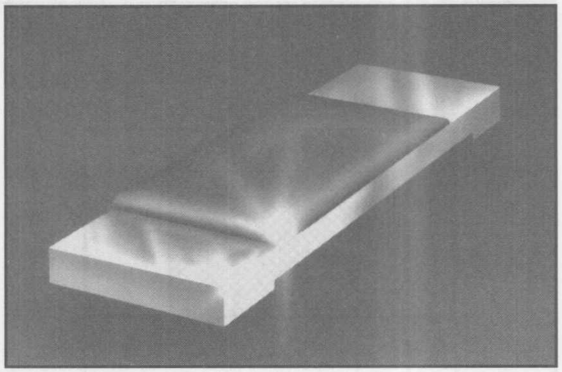
MODEL SERIES BCT

Distributor Item

Precision Thin Film

Chip Resistors

0805 & 1206



OUTSTANDING FEATURES

- **±0.1% Tolerance** - Low cost solution to precision requirements
- **Tight Dimensional Tolerances** - Ensure reliable high yield board assembly
- **Nickel Barrier Terminations** - Provide long term solder joint reliability
- **Exceptional Temperature Performance** - ±25ppm/°C

CONSTRUCTION

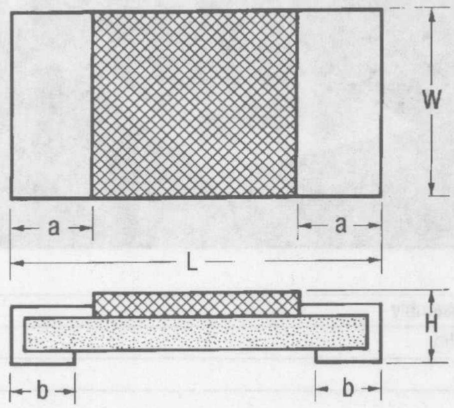
5

ELECTRICAL

Industry Style, Inch(mm)	**0805** (2012) & **1206** (3115)
Standard Resistance Tolerance at 25°C	±0.1% (B Tol.), ±.25% (C Tol.), ±.5% (D Tol.)
Standard Resistance Range, Ohms	100 to 100K, -E96 for 0.1% 10 to 100, -E96 for 0.25%
Operating Temperature Range	-55°C to +125°C
Power Rating, Watts* (Derates to 0 at 125°C)	**0805:** .100 at 70°C **1206:** .125 at 70°C
Temperature Coefficient of Resistance	±25ppm/°C
Operating Voltage, Max./Overload Voltage, Max.	**0805:** 75/150V dc **1206:** 150/300V dc

* Not to exceed Maximum Operating Voltage
Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)



	BCT 20	BCT 32
L	.079±.006 / 2.0±.15	.122±.004 / 3.1±0.1
W	.049+.004,-.002 / 1.25+0.1,-.05	.061+.004,-.002 / 1.55+.1-.05
H	.028 / .7 Max.	.028 / .7 Max.
a	.016±.008 / 0.4±.2	.016±.008 / 0.4±.2
b	.008 / 0.2 Min.	.008 / 0.2 Min.

ORDERING INFORMATION

BCT 20 1002 B T

Model Series — BCT

Size:
20 = 0805
32 = 1206

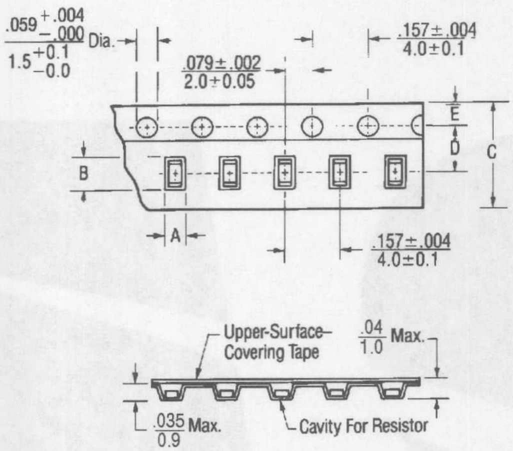
Resistance Code
Nominal Resistance Value
First 3 digits are significant
Fourth digit indicates number of trailing zeros

Tolerance Code
B = 0.1%
C = 0.25%
D = 0.5%

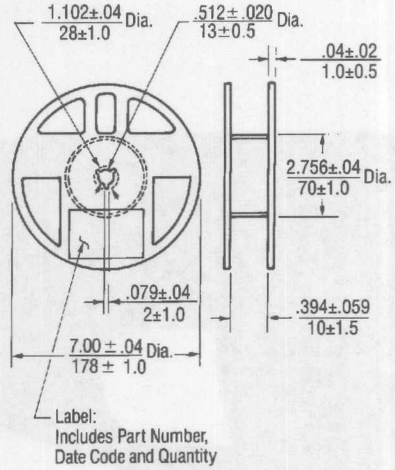
Packaging
T = Paper Tape
7" Reel Dia, 5K/Reel

PACKAGING (Inch/mm)

Paper Tape



Reel



Note: Reel capacity is 5,000 chips.

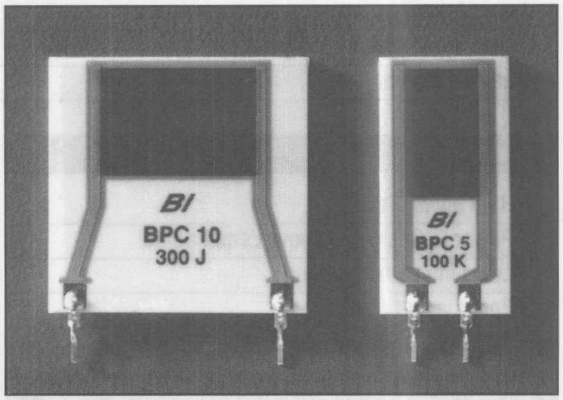
	A	B	C	D	E
BCT 20	.065±.006 / 1.65±.15	.098±.008 / 2.5±.2	.315±.008 / 8.0±.2	.138±.002 / 3.5±.054	.69±.004 / 1.75±.1
BCT 32	.079±.006 / 2.0±.15	.142±.008 / 3.6±.2	.315±.008 / 8.0±.2	.138±.002 / 3.5±.054	.69±.004 / 1.75±.1

MODEL

BPC SERIES

Non-Inductive Planar Thick Film Power Resistor Network

NEW PRODUCT



STANDARD TYPES

BPC 3	3 Watts, Nominal
BPC 5	5 Watts, Nominal
BPC 7	7.5 Watts, Nominal
BPC 10	10 Watts, Nominal

ELECTRICAL

Resistance Range, Ohms	**BPC 3, BPC 5, BPC 7:**1 to 200K, **BPC 10:** 3 to 200K
Standard Tolerances	±1%, ±2%, ±5%, ±10% (<10Ohms = ±2%, ±5%, ±10%)
Operating Temperature Range	-55°C to +125°C
Temperature Coefficient of Resistance, Maximum	±100ppm/°C
Power Ratings, Watts	3W, 5W, 7.5W, 10W
Operating Voltage, Maximum	300 V ac, 500V dc
Peak Current	20 X Rated Current up to 8 ms (ΔR ±0.5%)

ENVIRONMENTAL (PER MIL-R-83401)

Thermal Shock	ΔR 0.50%
Terminal Strength	ΔR 0.25%
Moisture Resistance	ΔR 0.25%
Mechanical Shock	30G's , ΔR 0.25%
Vibration	10G's, 10 to 500 Hz ΔR 0.25%
Low Temperature Storage	ΔR 0.25%
High Temperature Exposure	ΔR 0.25%
Load Life, 1,000 Hours	ΔR 1.00%
Resistance to Solder Heat	ΔR 0.25%
Dielectric Withstanding Voltage, Minimun	5,000 Vdc
Marking Permanency	MIL-STD-202, Method 215
Lead Solderability	MIL-STD-202, Method 208
Flammability	UL 94V-0 Rated
Storage	-55°C to +155°C

Specifications subject to change without notice.

MECHANICAL

Lead Material	Solder Tinned Copper Alloy
Substrate Material	96% Alumina
Resistor Material	Ruthenium Oxide

FEATURES

- High power density
- Power is dissipated above circuit board
- Low temperature solder
- Board layout flexibility

APPLICATIONS

- In rush current limiters
- Power supply preloads
- Snubber circuits
- UPS systems

ORDERING INFORMATION

BPC 10 103 G

Model Series

Power Rating:
3 = 3 Watts
5 = 5 Watts
7 = 7.5 Watts
10 = 10 Watts

Tolerance Code:
F = 1%
G = 2%
J = 5%
K = 10%

Resistance Code
First 2 digits are significant. Last digit denotes number of trailing zeros.
For F Tol. first 3 digits are significant. Last digit denotes number of trailing zeros.

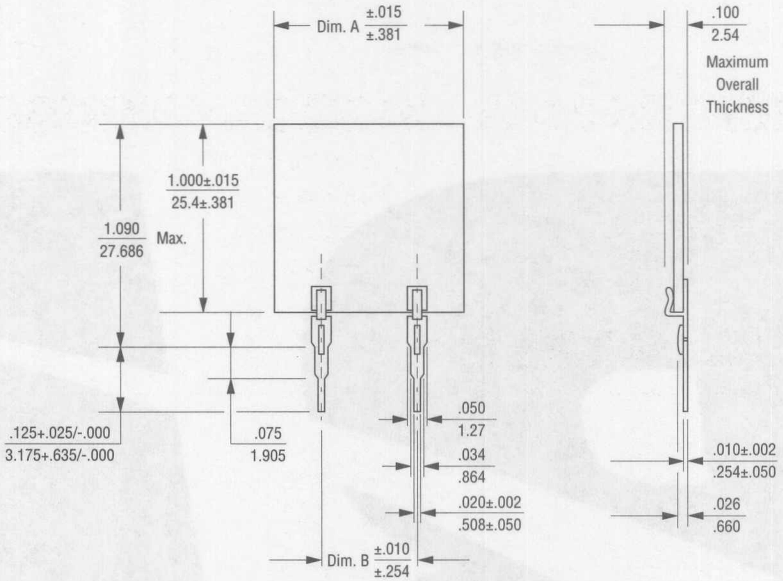
STANDARD RESISTANCE VALUES (OHMS)

Value	1	2	5	10	20	50	100	200	500	1K	2K	5K	10K	20K	50K
Code	1R0	2R0	5R0	100	200	500	101	201	501	102	202	502	103	203	503

PACKAGING

Standard:	BPC 3, BPC 5, BPC 7 = 200 per box
	BPC 10 = 100 per box

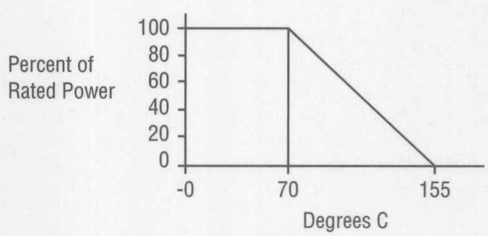
OUTLINE DIMENSIONS (Inch/mm)



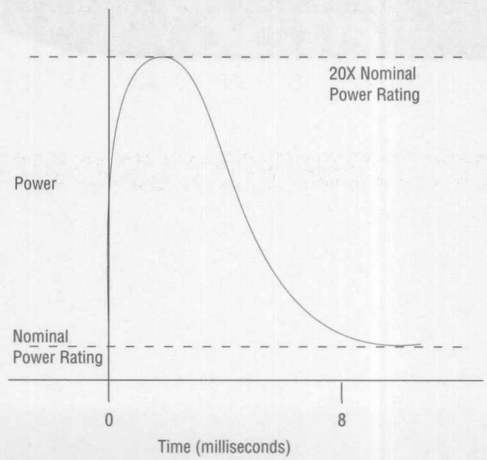
Model	BPC 3	BPC 5	BPC 7	BPC 10
Dim. A	0.40 10.16	0.50 12.70	0.75 19.05	1.00 25.40
Dim. B	0.20 5.08	0.20 5.08	0.50 12.70	0.80 20.32

5

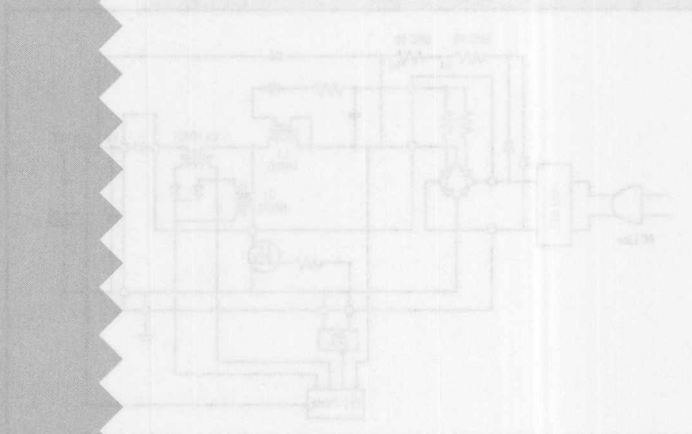
POWER DERATING CURVE



OVERLOAD CHARACTERISTICS



Application Notes
Discrete Components



BPC APPLICATIONS

INRUSH CURRENT LIMITING

The BPC may be used to limit inrush current when a power supply is switched on. In Figure 1 is a typical PFC circuit in which two BPC 10 resistors in series function as inrush current limiters.

SNUBBER CIRCUIT

The BPC may be used in series with a capacitor in a snubber circuit to filter spikes in the rising and falling edges of square waves. In Figure 2 a 500Ω BPC 3 is used.

STARTUP CIRCUIT

Figure 2 also includes a startup circuit that provides 18 volts to the PWM while the power supply is turning on. In this case, a 50KΩ BPC 5 is utilized.

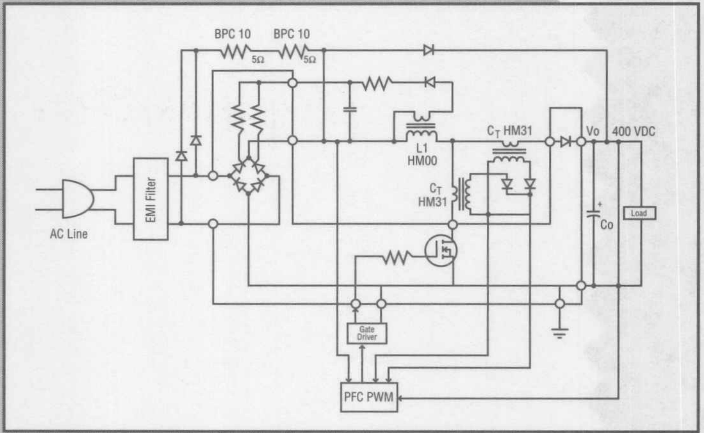


FIGURE 1. Typical PFC Circuit

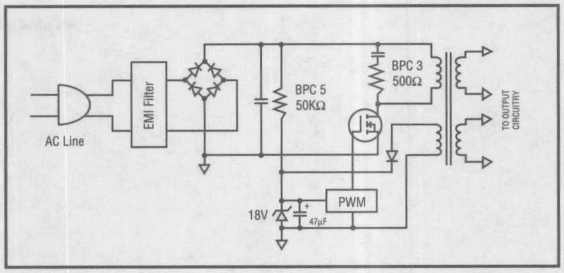


FIGURE 2. Typical Startup and Snubber Circuits

Magnetics

6

MAGNETIC COMPONENTS CAPABILITIES

	Main Line Transformer		Inductor		EMI Filter		Gate Drive Transformer (Mosfet)	Current Sense	
	Power	Dist'd	Power	Dist'd	Differential	Common Mode		Inductor	Transformer
Application Related									
- Line Input (70-400V)	✓				✓	✓			
- Oper. Freq. 20-500 KHz	✓	✓		✓			✓	✓	✓
- DC / DC		✓		✓					
- International Safety	✓		✓		✓	✓	✓	✓	✓
Core: Mat'l & Config.									
- Ferrite: Buckle						✓			
EE	✓	✓	✓	✓		✓	✓		
ETD	✓	✓							
EC	✓	✓							
PQ	✓	✓							
POT		✓							
RM		✓							
UU						✓	✓		✓
SLUG (Drum)			✓	✓	✓				
Toroid		✓				✓	✓	✓	✓
- Pwd. Iron: Toroid			✓	✓	✓				
Packaging									
- Low Profile SMD		✓		✓		✓	✓		✓
- Encapsulated		✓						✓	✓
- Through Hole (3/8" to 2" Cube)	✓	✓	✓	✓	✓	✓	✓	✓	✓
- SMD Chip				✓	✓				
Catalog Equiv. (HM)			11, 12, 13, 15, 50, 51 BCL, BML		11, 12, 13, BCL, BML	18, 19, 28	41	31	32, 33

Contact Product Marketing for Design Assistance.

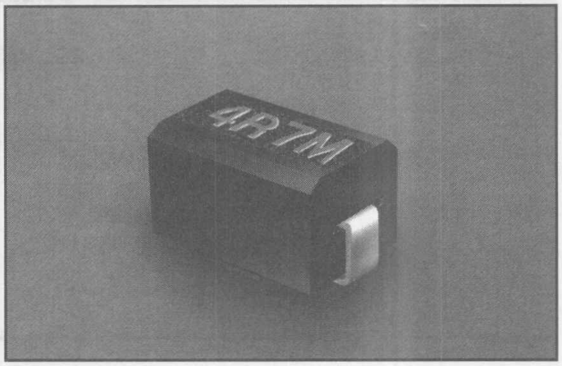
MODEL BCL 453232

Distributor Item

Surface Mount

Inductors

Size: 1812



OUTSTANDING FEATURES

- Wound ferrite core for low DCR
- Molded construction provides superior strength and moisture resistance
- Accurate dimensions for automatic handling and machine placement
- Compatible with vapor phase and infra-red reflow soldering
- Wide inductance range in a small package

APPLICATIONS

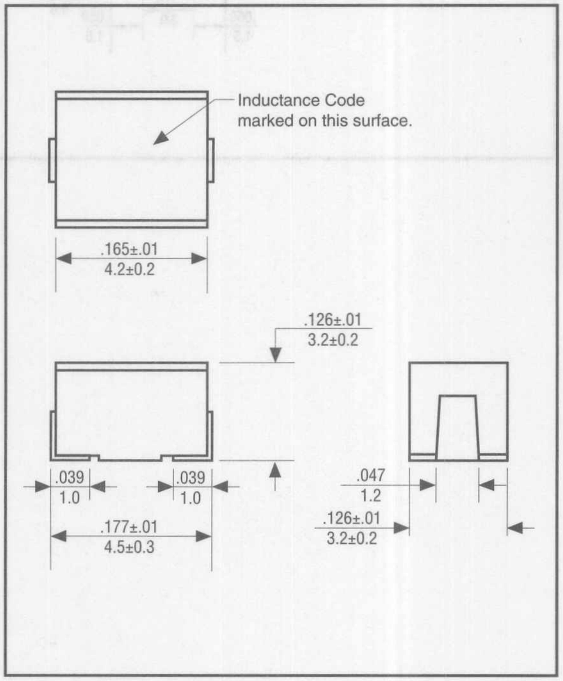
- Instrumentation
- Mobil Communication Equipment
- Notebook Computer
- Video and Audio Equipment
- Video Games
- Medical Equipment

ELECTRICAL/ENVIRONMENTAL

Inductance Range	0.1µH to 1,000µH
Standard Tolerance	±10%(<1.0µH = ±20%)
Storage Temperature	-40°C to +100°C
Operating Temperature	-40°C to +100°C
Ambient Temperature, Maximum	80°C
Resistance to Solder Heat	260°C for 10 sec.
Terminal Pull Strength, Minimum	1.0 KG

Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)



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BCL 453232 330 K

Model Series

Inductance Code

First 2 digits are significant. Last digit denotes the number of trailing zeros. Values below 10µH, "R" denotes the decimal point.

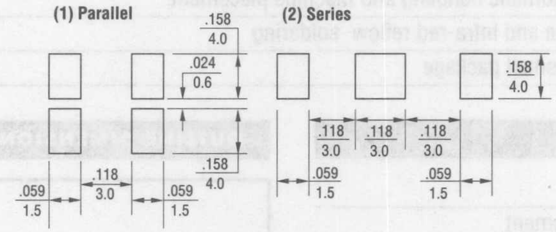
Inductance Tolerance

J = 5%

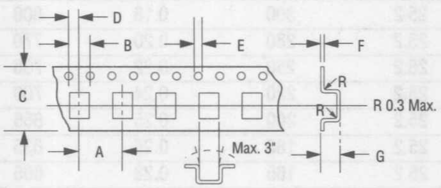
K = 10%

M = 20%

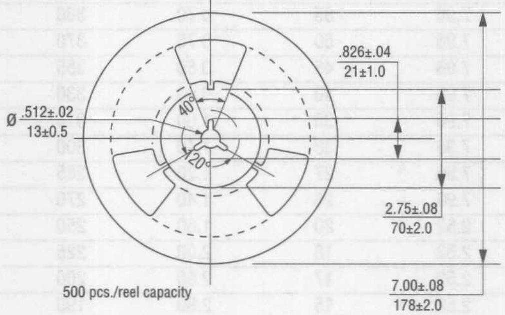
RECOMMENDED PC BOARD LAYOUT (Inch/mm)



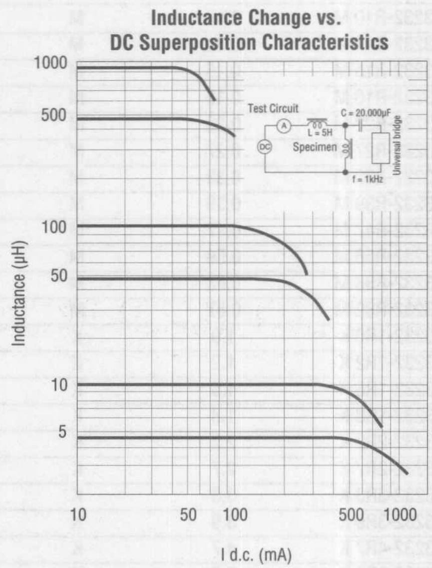
PACKAGING (Inch/mm)

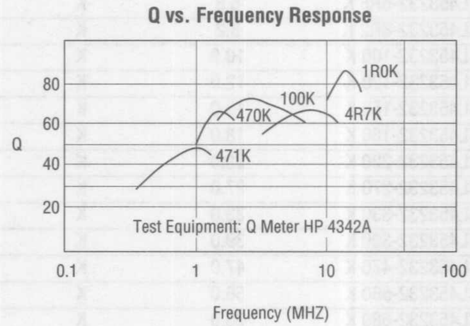


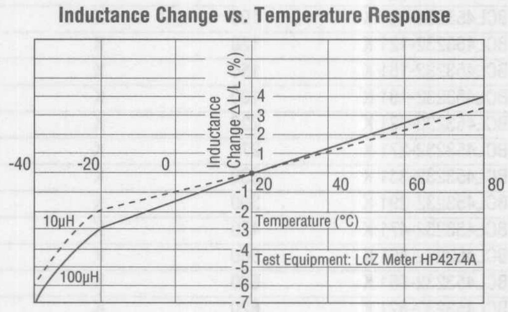
	A	B	C	D	E	F	G
Inch	.315	.158	.472	.079	.059	.012	.138
mm	8.0	4.0	12.0	2.0	1.5	0.3	3.5



PERFORMANCE







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SPECIFICATIONS

Model	Inductance (µH)	Tolerance	Q Min.	Test Freq. (mHz)	SRF Min. (mHz)	RDC Max (OHM)	Rated Current IDC (mA)
BCL453232-R10 M	0.10	M	35	25.2	300	0.18	800
BCL453232-R12 M	0.12	M	35	25.2	280	0.20	770
BCL453232-R15 M	0.15	M	35	25.2	250	0.22	730
BCL453232-R18 M	0.18	M	35	25.2	220	0.24	700
BCL453232-R22 M	0.22	M	40	25.2	200	0.25	665
BCL453232-R27 M	0.27	M	40	25.2	180	0.26	635
BCL453232-R33 M	0.33	M	40	25.2	165	0.28	605
BCL453232-R39 M	0.39	M	40	25.2	150	0.30	575
BCL453232-R47 M	0.47	M	40	25.2	145	0.32	545
BCL453232-R56 M	0.56	M	40	25.2	140	0.36	520
BCL453232-R68 M	0.68	M	40	25.2	135	0.40	500
BCL453232-R82 M	0.82	M	40	25.2	130	0.45	475
BCL453232-1R0 K	1.0	K	50	7.96	100	0.50	450
BCL453232-1R2 K	1.2	K	50	7.96	80	0.55	430
BCL453232-1R5 K	1.5	K	50	7.96	70	0.60	410
BCL453232-1R8 K	1.8	K	50	7.96	60	0.65	390
BCL453232-2R2 K	2.2	K	50	7.96	55	0.70	380
BCL453232-2R7 K	2.7	K	50	7.96	50	0.75	370
BCL453232-3R3 K	3.3	K	50	7.96	45	0.80	355
BCL453232-3R9 K	3.9	K	50	7.96	40	0.90	330
BCL453232-4R7 K	4.7	K	50	7.96	35	1.00	315
BCL453232-5R6 K	5.6	K	50	7.96	33	1.10	300
BCL453232-6R8 K	6.8	K	50	7.96	27	1.20	285
BCL453232-8R2 K	8.2	K	50	7.96	25	1.40	270
BCL453232-100 K	10.0	K	50	2.52	20	1.60	250
BCL453232-120 K	12.0	K	50	2.52	18	2.00	225
BCL453232-150 K	15.0	K	50	2.52	17	2.50	200
BCL453232-180 K	18.0	K	50	2.52	15	2.80	190
BCL453232-220 K	22.0	K	50	2.52	13	3.20	180
BCL453232-270 K	27.0	K	50	2.52	12	3.60	170
BCL453232-330 K	33.0	K	50	2.52	11	4.00	160
BCL453232-390 K	39.0	K	50	2.52	10	4.50	150
BCL453232-470 K	47.0	K	50	2.52	10	5.00	140
BCL453232-560 K	56.0	K	50	2.52	9.0	5.50	135
BCL453232-680 K	68.0	K	50	2.52	9.0	6.00	130
BCL453232-820 K	82.0	K	50	2.52	8.0	7.00	120
BCL453232-101 K	100	K	40	0.796	8.0	8.00	110
BCL453232-121 K	120	K	40	0.796	6.0	8.00	110
BCL453232-151 K	150	K	40	0.796	5.0	9.00	105
BCL453232-181 K	180	K	40	0.796	5.0	9.50	102
BCL453232-221 K	220	K	40	0.796	4.0	10.0	100
BCL453232-271 K	270	K	40	0.796	4.0	12.0	92
BCL453232-331 K	330	K	40	0.796	3.5	14.0	85
BCL453232-391 K	390	K	40	0.796	3.0	16.0	80
BCL453232-471 K	470	K	40	0.796	3.0	26.0	62
BCL453232-561 K	560	K	30	0.796	3.0	30.0	50
BCL453232-681 K	680	K	30	0.796	3.0	30.0	50
BCL453232-821 K	820	K	30	0.796	2.5	35.0	30

MODEL BMB SERIES

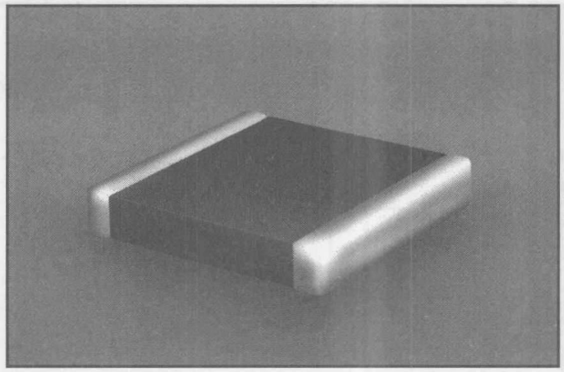
Distributor Item

Surface Mount

Multi-Layer

Chip Beads

Sizes: 0805 to 1812



OUTSTANDING FEATURES

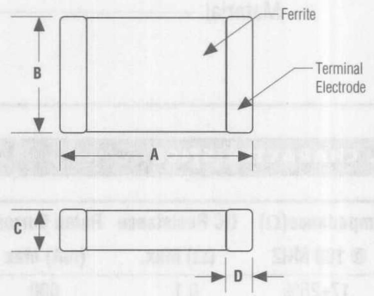
- Monolithic structures for high reliability
- Choice of various sizes and materials for a widerange of application
- Designed to offer high impedance for volume
- Compatible with vapor phase and infra-red reflow soldering

APPLICATIONS

- Instrumentation
- Mobile communication equipment
- Notebook computers
- Video and audio equipment
- Video games
- Medical equipment

Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)



Inch/mm

Model	A Dim.	B Dim.	C Dim.	D Dim.
BMB 201209	.079±.01	.047±.01	.035±.01	.020±.01
(0805)	2.0±0.20	1.2±0.20	.09±0.20	0.5±0.30
BMB 321611	.126±.01	.063±.01	.043±.01	.020±.01
(1206)	3.2±0.20	1.6±0.20	1.1±0.20	0.5±0.30
BMB 321616	.126±.01	.063±.01	.063±.01	.020±.01
(1206)	3.2±0.20	1.6±0.20	1.6±0.20	0.5±0.30
BMB 322513	.126±.01	.098±.01	.051±.01	.020±.01
(1210)	3.2±0.20	2.5±0.20	1.3±0.20	0.5±0.30
BMB 453215	.177±.01	.126±.01	.051±.01	.020±.01
(1812)	4.5±0.25	3.2±0.25	1.3±0.25	0.5±0.30
BMB 451616	.177±.01	..063±.01	.063±.01	..020±.01
(1806)	4.5±0.25	1.6±0.20	1.6±0.20	0.5±0.30

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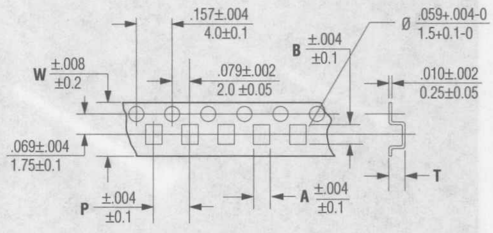
PACKAGING (Inch/mm)



Tape Material: Polyestyrene

Reel Capacity is 2,000 pcs., except BMB 453215 which is 1,000

Part #	A	B	W	P	T
BMB 453215	.142	.193	.472	.315	.075
	3.60	4.90	12	8	1.9
BMB 451616	.075	.193	.472	.158	.079
	1.90	4.90	12	4	2.0
BMB 322513	.114	.142	.315	.158	.067
	2.90	3.60	8	4	1.7
BMB 322511	.075	.138	.315	.158	.059
	1.90	3.50	8	4	1.5
BMB 321616	.075	.138	.315	.158	.059
	1.90	3.50	8	4	1.5
BMB 321611	.075	.138	.315	.158	.059
	1.90	3.50	8	4	1.5
BMB 201209	.059	.091	.315	.158	.051
	1.5	2.30	8	4	1.3

ORDERING INFORMATION

BMB V 201209

Model Series — BMB

Material — V

Dimensions: Length (A) x Width (B) x Thickness (C) — 201209

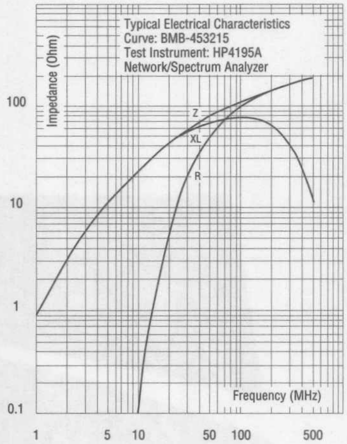
ELECTRICAL CHARACTERISTICS

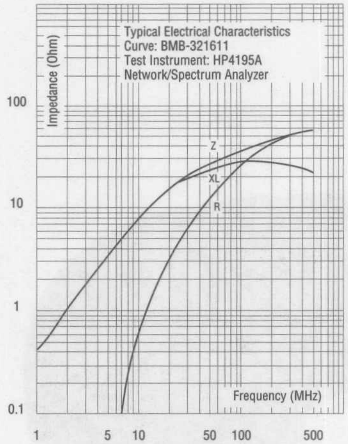
Part #	Impedance(Ω) @ 100 MHZ	DC Resistance (Ω) Max.	Rated Current (mA) Max
BMB-V-201209	17±25%	0.1	600
BMB-A-321611	26±25%	0.2	500
BMB-V-321611	31±25%	0.2	500
BMB-E-321611	600±25%	1.0	200
BMB-C-321616	70±25%	0.5	200
BMB-A-322513	52±25%	0.3	400
BMB-V-322513	60±25%	0.3	400
BMB-A-453215	120±25%	0.4	300
BMB-V-453215	125±25%	0.4	300
BMB-D-453215	70±25%	0.4	300
BMB-V-451616	60±25%	0.3	300
BMB-F-451616	80±25%	0.3	500
BMB-G-451616	150±25%	0.7	200

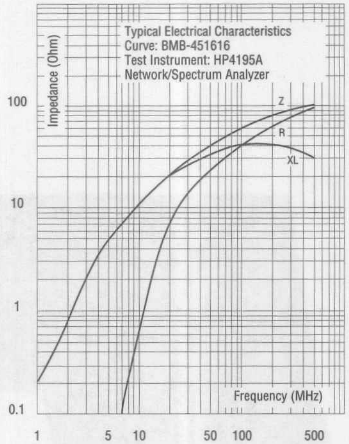
MATERIAL CHARACTERISTICS

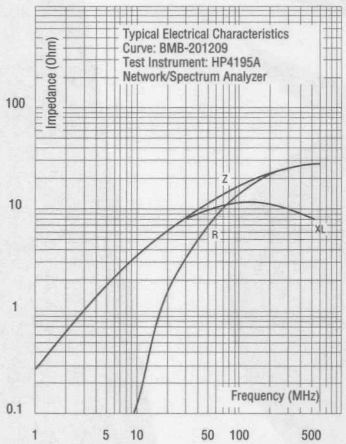
	V	A
Initial Permeability, µiac	200	500
Permeability,Maximum, µm	450	900
Saturation Flux Density @ 10 Oe, Gauss	1400	1500
Curie Temperature, ˚C	>130	>100
Volume Resistivity, Ω-m	10^5	10^5
Temperature Coefficient of µiac 20˚C ~ 80˚C, 10^{-6}/˚C	13	5
Density, g/cm³	4.8	4.8

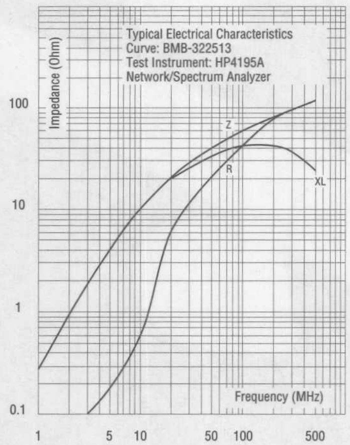
PERFORMANCE EXAMPLES FOR 'V' MATERIAL











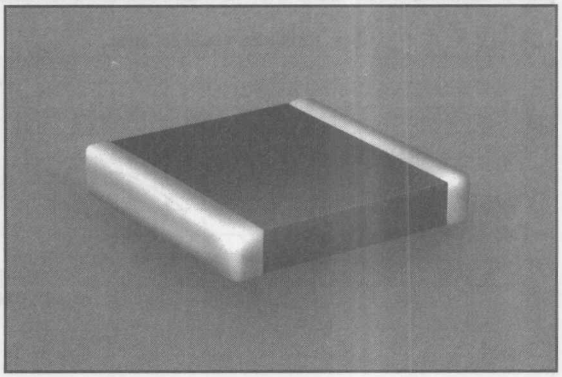
MODEL BML SERIES

Surface Mount

Multi-Layer

Chip Inductors

Size: 1206



OUTSTANDING FEATURES

- Tight dimensional tolerances and a small package make this chip ideal for high density installation
- Monolithic structure for high reliability
- Magnetic shielded construction minimizes coupling to other components
- Compatible with vapor phase and infra-red reflow soldering

APPLICATIONS

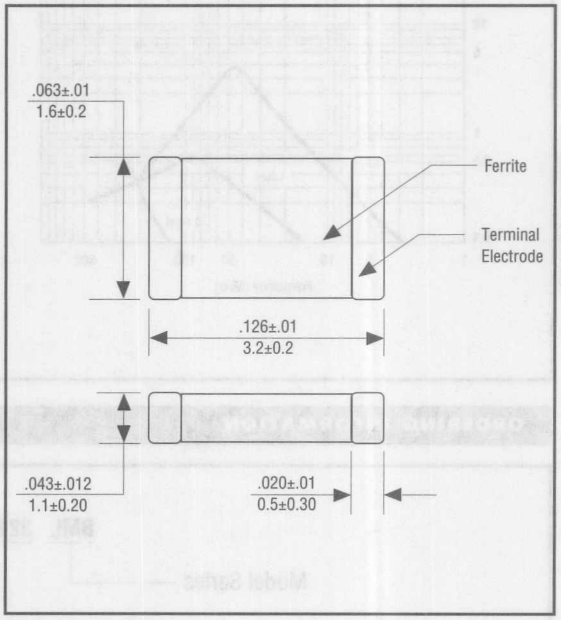
- Instrumentation
- Mobile communication equipment
- Notebook computer
- Video and audio equipment
- Video games
- Medical equipment

ELECTRICAL/ENVIRONMENTAL

Inductance Range	0.12µH to 12.0µH
Standard Tolerance	±10% (<0.82µH = ±20%)
Storage Temperature	-40°C to +85°C
Operating Temperature	-20°C to +85°C
Ambient Temperature, Maximum	80°C
Resistance to Solder Heat	260°C for 10 sec.
Resistance to Solvent	Per MIL-STD-202F

Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)



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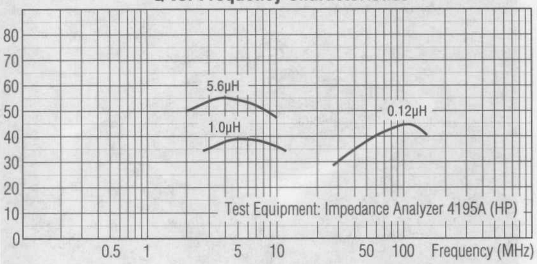
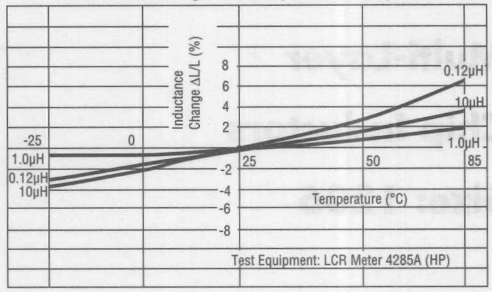
PERFORMANCE

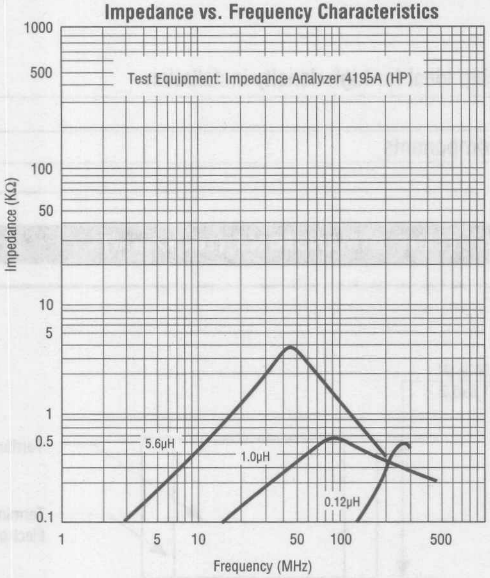
Q vs. Frequency Characteristics



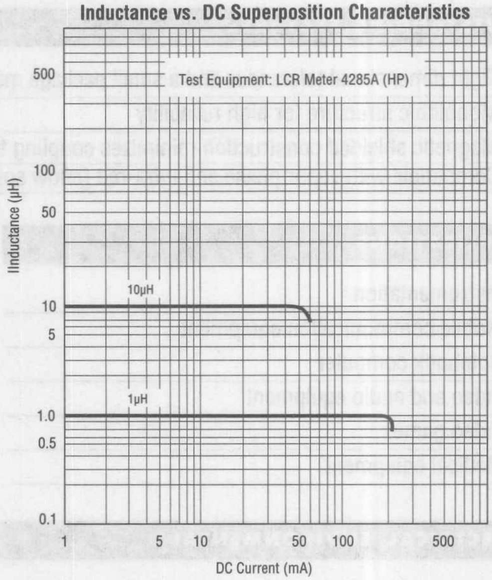
Inductance Change vs. Temperature Response



Impedance vs. Frequency Characteristics



Inductance vs. DC Superposition Characteristics



ORDERING INFORMATION

BML 321611 1R0 X

- Model Series — BML
- Dimensions — 321611
- Inductance: 1.00μH — 1R0
- Tolerance: K = ±10%, M = ±20% — X

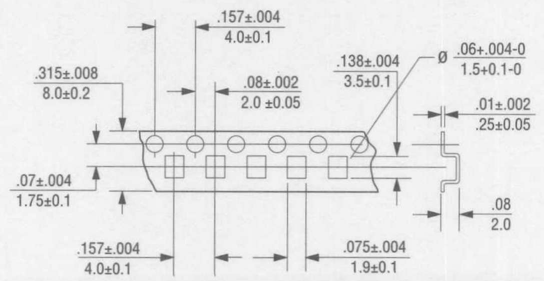
SPECIFICATIONS

Model	Inductance (µH)	Q Min.	Test Freq. (MHZ)	SRF Min. (MHZ)	RDC Max. (OHM)	Rated Current IDC (mA)*
BML321611 R12 X	0.12±20%	20	25	220	0.3	100
BML321611 R15 X	0.15±20%	20	25	200	0.3	100
BML321611 R18 X	0.18±20%	20	25	185	0.4	100
BML321611 R22 X	0.22±20%	20	25	170	0.4	100
BML321611 R27 X	0.27±20%	20	25	150	0.5	100
BML321611 R33 X	0.33±20%	20	25	145	0.6	100
BML321611 R39 X	0.39±20%	25	25	135	0.5	100
BML321611 R47 X	0.47±20%	25	25	125	0.6	100
BML321611 R56 X	0.56±20%	25	25	115	0.7	100
BML321611 R68 X	0.68±20%	25	25	105	0.8	100
BML321611 R82 X	0.82±20%	25	25	100	0.9	100
BML321611 1R0 X	1.0±20% or ±10%	25	10	75	0.4	100
BML321611 1R2 X	1.2±20% or ±10%	25	10	65	0.5	100
BML321611 1R5 X	1.5±20% or ±10%	30	10	60	0.5	50
BML321611 1R8 X	1.8±20% or ±10%	30	10	55	0.5	50
BML321611 2R2 X	2.2±20% or ±10%	30	10	50	0.6	50
BML321611 2R7 X	2.7±20% or ±10%	30	10	45	0.6	50
BML321611 3R3 X	3.3±20% or ±10%	30	10	41	0.7	50
BML321611 3R9 X	3.9±20% or ±10%	30	10	36	0.8	50
BML321611 4R7 X	4.7±20% or ±10%	30	10	35	0.9	50
BML321611 5R6 X	5.6±20% or ±10%	35	4	32	0.7	25
BML321611 6R8 X	6.8±20% or ±10%	35	4	29	0.8	25
BML321611 8R2 X	8.2±20% or ±10%	35	4	26	0.9	25
BML321611 100 X	10.0±20% or ±10%	35	2	24	1.0	25
BML321611 120 X	12.0±20% or ±10%	35	2	22	1.05	15

Tolerance: K = ±10%, M=±20%

* Current Rating: The current at which a smaller change of inductance will occur due to either temperature increases or DC Current Superposition.

PACKAGING (Inch/mm)



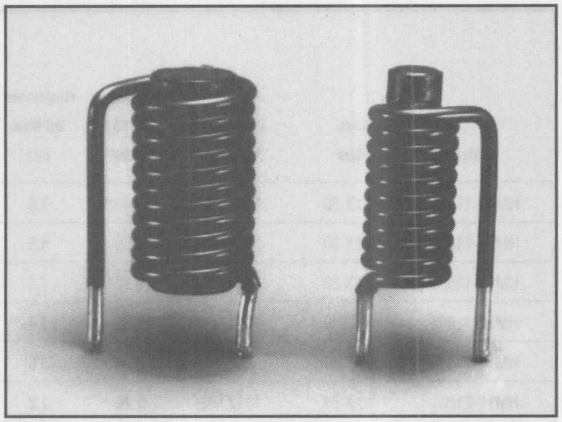
Tape Material: Polystyrene Supplied on 7" Diameter Reels. Reel capacity is 3,000 pcs

6

MODEL SERIES HM11

Inductor

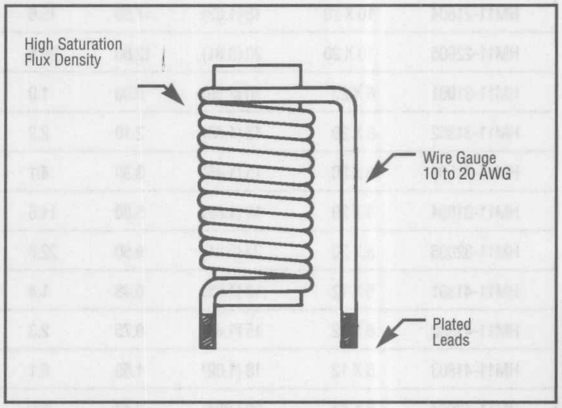
Vertical Mount



FEATURES

- High saturation flux density
- Small size
- Single layer designs
- Available without core
- Custom designs available

CONSTRUCTION



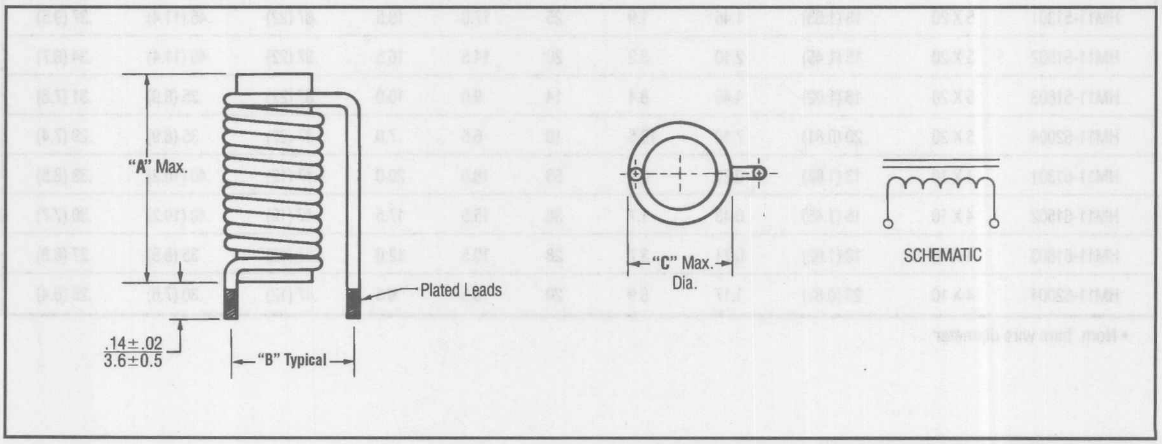
APPLICATIONS

- Switch mode power supplies
- EMI suppression
- Output ripple current filters
- High current oscillator tank circuits

ELECTRICAL/MECHANICAL/ENVIRONMENTAL

Operating Temperature Range	-25° to + 105°C
Temperature Rise Maximum	45°C

OUTLINE DIMENSIONS (Inch/mm)



Specifications subject to change without notice.

SPECIFICATIONS

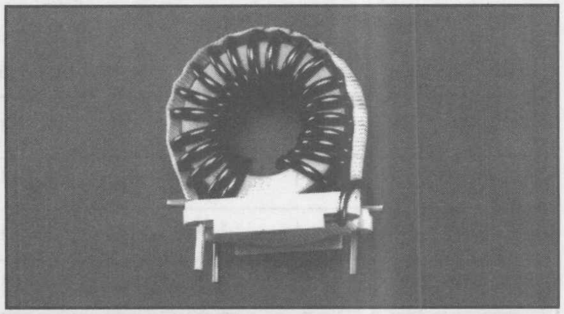
Model	Core Size	Wire Gauge AWG(mm)•	Inductance µH at 10 KHz ±25%	Resistance DC Max. mΩ	I SAT (DC Amps) Approx.	Max. Current (DC Amps) at 35°C Rise	Max. Current (DC Amps) at 45°C Rise	Mechanical Outline Dimensions: inches (mm) A	B	C
HM11-11001	10 X 30	10 (2.59)	3.40	1.8	48	23.5	26.5	1.26 (32)	.75 (19.0)	.63 (16.0)
HM11-11302	10 X 30	13 (1.83)	5.90	4.5	36	13.0	15.0	1.26 (32)	.65 (16.5)	.57 (14.5)
HM11-11503	10 X 30	15 (1.45)	9.20	7.5	28	10.5	12.0	1.26 (32)	.60 (15.2)	.54 (13.7)
HM11-11804	10 X 30	18 (1.02)	17.80	21.4	20	7.0	8.0	1.26 (32)	.55 (14.0)	.50 (12.8)
HM11-12005	10 X 30	20 (0.81)	28.00	43.0	16	5.5	6.5	1.26 (32)	.55 (14.0)	.49 (12.4)
HM11-21001	10 X 20	10 (2.59)	1.20	1.2	85	25.0	28.0	.87 (22)	.75 (19.0)	.63 (16.0)
HM11-21302	10 X 20	13 (1.83)	2.50	3.4	60	14.0	16.0	.87 (22)	.65 (16.5)	.57 (14.5)
HM11-21503	10 X 20	15 (1.45)	3.9	5.5	46	11.5	13.5	.87 (22)	.60 (15.2)	.54 (13.7)
HM11-21804	10 X 20	18 (1.02)	7.50	15.0	30	8.0	9.0	.87 (22)	.55 (14.0)	.50 (12.8)
HM11-22005	10 X 20	20 (0.81)	12.60	30.6	22	5.0	5.5	.87 (22)	.55 (14.0)	.49 (12.4)
HM11-31001	8 X 20	10 (2.59)	0.90	1.0	72	28.0	31.0	.87 (22)	.65 (16.5)	.55 (14.0)
HM11-31302	8 X 20	13 (1.83)	2.10	2.2	45	14.5	17.0	.87 (22)	.55 (14.0)	.49 (12.5)
HM11-31503	8 X 20	15 (1.45)	3.30	4.1	35	11.5	13.5	.87 (22)	.55 (14.0)	.46 (11.7)
HM11-31804	8 X 20	18 (1.02)	5.80	11.6	26	8.0	9.0	.87 (22)	.50 (12.7)	.43 (10.8)
HM11-32005	8 X 20	20 (0.81)	9.50	22.8	22	5.5	6.5	.87 (22)	.45 (11.4)	.41 (10.4)
HM11-41301	6 X 12	13 (1.83)	0.48	1.4	65.	13.0	15.0	.55 (14)	.50 (12.7)	.41 (10.5)
HM11-41502	6 X 12	15 (1.45)	0.75	2.3	50	10.0	12.0	.55 (14)	.45 (11.4)	.38 (9.7)
HM11-41803	6 X 12	18 (1.02)	1.65	6.1	32	8.0	9.0	.55 (14)	.40 (10.2)	.35 (8.8)
HM11-42004	6 X 12	20 (.081)	2.48	6.0	23	7.5	8.5	.55 (14)	.40 (10.2)	.33 (8.4)
HM11-51301	5 X 20	13 (1.83)	1.45	1.9	25	17.0	19.5	.87 (22)	.45 (11.4)	.37 (9.5)
HM11-51502	5 X 20	15 (1.45)	2.10	3.2	20	14.5	16.5	.87 (22)	.45 (11.4)	.34 (8.7)
HM11-51803	5 X 20	18 (1.02)	4.40	8.4	14	9.0	10.0	.87 (22)	.35 (8.9)	.31 (7.8)
HM11-52004	5 X 20	20 (0.81)	7.10	16.5	10	6.5	7.0	.87 (22)	.35 (8.9)	.29 (7.4)
HM11-61301	4 X 10	13 (1.83)	0.21	0.9	53	18.0	20.0	.47 (12)	.40 (10.2)	.33 (8.5)
HM11-61502	4 X 10	15 (1.45)	0.43	1.7	38	15.5	17.5	.47 (12)	.40 (10.2)	.30 (7.7)
HM11-61803	4 X 10	18 (1.02)	0.71	3.7	28	10.5	12.0	.47 (12)	.35 (8.9)	.27 (6.8)
HM11-62004	4 X 10	20 (0.81)	1.17	6.9	20	8.5	9.5	.47 (12)	.30 (7.6)	.25 (6.4)

• Nom. bare wire diameter

MODEL SERIES HM12

Output Toroidal Inductor

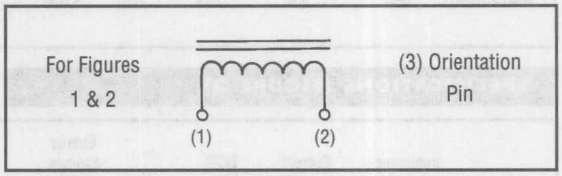
With Mounting Base



FEATURES

- High performance powdered iron cores for excellent energy storage characteristics
- Cost effective design
- Custom designs available

SCHEMATIC



APPLICATIONS

- Switching power supply
- Motor control circuit
- Differential EMI filter
- Output ripple current filter

ELECTRICAL/MECHANICAL/ENVIRONMENTAL

Insulation Resistance Minimum	100 Megohms
Operating Temperature Range	–25°C to +105°C
Insulation System	Class B, 130°C

FIGURE 1 (Inch/mm)

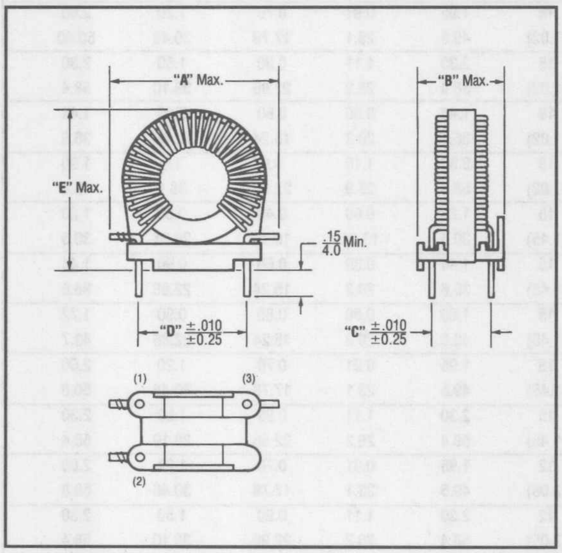
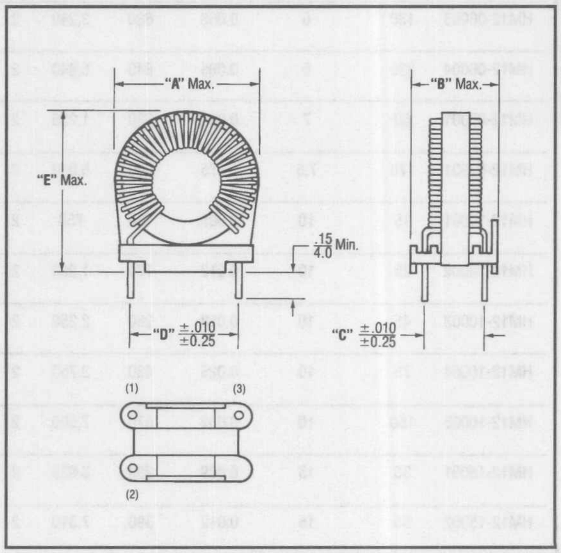


FIGURE 2 (Inch/mm)



Specifications subject to change without notice.

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SPECIFICATIONS (FIGURE 1)

Model	Inductance Typical (µH)	Current DCI Max. (Amps)	DCR Max. (Ohms)	ET_{op} (V-µSec)	Energy Storage (µJ) Min.	Fig.	Wire Gauge AWG (mm)*	Mechanical Outline Dimensions: inches/mm A	B	C	D	E
HM12-01001	92	1	0.35	77	46	1	28	1.20	0.62	0.4	0.8	0.75
							(0.32)	30.5	15.8	10.16	20.32	19.05
HM12-01002	700	1	0.89	400	350	1	28	1.00	0.62	0.4	0.8	1.2
							(0.32)	25.4	15.8	10.16	20.32	30.48
HM12-01003	1,700	1	1.45	730	850	1	28	1.60	0.92	0.7	1.2	1.58
							(0.32)	40.64	23.37	17.78	30.48	40.13
HM12-02501	77	2.5	0.11	90	240	1	24	1.20	0.62	0.4	0.8	0.95
							(0.51)	30.5	15.8	10.16	20.32	24.13
HM12-02502	320	2.5	0.29	350	1,000	1	24	1.30	0.82	0.6	0.9	1.35
							(0.51)	33.0	20.8	15.24	22.86	34.30
HM12-02503	960	2.5	0.63	870	3,000	1	24	2.30	1.12	0.9	1.5	1.85
							(0.51)	58.4	28.5	22.86	38.1	47.0

SPECIFICATIONS (FIGURE 2)

Model	Inductance Typical (µH)	Current DCI Max. (Amps)	DCR Max. (Ohms)	ET_{op} (V-µSec)	Energy Storage (µJ) Min.	Fig.	Wire Gauge AWG (mm)*	Mechanical Outline Dimensions: inches/mm A	B	C	D	E
HM12-03501	275	4	0.200	500	2,200	2	21	1.30	0.90	0.60	0.90	1.40
							(0.79)	33.0	22.9	15.24	22.86	38.7
HM12-03502	475	4	0.130	600	2,138	2	19	1.60	0.80	0.60	0.90	1.72
							(0.91)	40.6	20.3	15.24	22.86	43.7
HM12-06001	35	6	0.025	200	630	2	18	1.20	0.60	0.40	0.80	1.20
							(1.02)	30.5	15.24	10.16	20.32	30.5
HM12-06002	100	6	0.048	400	1,800	2	18	1.60	0.80	0.60	0.90	1.20
							(1.02)	40.6	20.3	15.24	22.86	30.5
HM12-06003	180	6	0.068	620	3,240	2	18	1.95	0.91	0.70	1.20	2.00
							(1.02)	49.5	23.1	17.78	30.48	50.80
HM12-06004	330	6	0.095	840	5,940	2	18	2.30	1.11	0.90	1.50	2.30
							(1.02)	58.4	28.2	22.85	38.10	58.4
HM12-07001	50	7	0.032	230	1,225	2	18	1.44	0.80	0.60	0.90	1.44
							(1.02)	36.8	20.3	15.24	22.86	36.6
HM12-07501	178	7.5	0.075	500	5,000	2	18	2.30	1.10	0.9	1.5	1.90
							(1.02)	58.4	27.9	22.86	38.1	48.3
HM12-10001	15	10	0.009	135	750	2	15	1.20	0.60	0.40	0.80	1.20
							(1.45)	30.5	15.24	10.16	20.34	30.5
HM12-10002	25	10	0.012	170	1,250	2	15	1.44	0.80	0.60	0.90	1.44
							(1.45)	36.6	20.3	15.24	22.86	36.6
HM12-10003	45	10	0.018	280	2,250	2	15	1.60	0.80	0.60	0.90	1.72
							(1.45)	40.6	20.3	15.24	22.86	43.7
HM12-10004	75	10	0.025	430	3,750	2	15	1.95	0.91	0.70	1.20	2.00
							(1.45)	49.5	23.1	17.78	30.48	50.8
HM12-10005	150	10	0.032	570	7,500	2	15	2.30	1.11	0.90	1.50	2.30
							(1.45)	58.4	28.2	22.85	38.10	58.4
HM12-15001	35	15	0.009	290	3,935	2	12	1.95	0.91	0.70	1.20	2.00
							(2.05)	49.5	23.1	17.78	30.48	50.8
HM12-15002	65	15	0.012	390	7,310	2	12	2.30	1.11	0.90	1.50	2.30
							(2.05)	58.4	28.2	22.95	38.10	58.4
HM12-16001	20	16	0.0065	190	2,560	2	12	1.60	0.80	0.60	0.90	1.32
							(2.05)	40.6	28.3	15.24	22.86	43.7

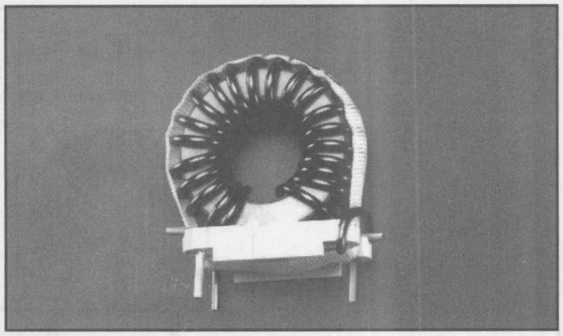
* Nom. bare wire diameter

MODEL SERIES HM13

High Inductance

High Frequency

Toroidal Inductors



FEATURES

- High performance low loss cores for excellent energy storage characteristics at 300 KHz and high ET
- Cost effective design
- Industry standard header
- Custom designs available

ELECTRICAL/MECHANICAL/ENVIRONMENTAL

Insulation Resistance Minimum	100 Megohms
Operating Temperature Range	–25°C to +105°C
Insulation System	Class B, 130°C

APPLICATIONS

- Switching power supply
- Motor control circuit
- Differential EMI Filter
- Output ripple current filter

SCHEMATIC

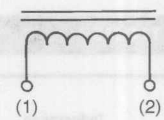
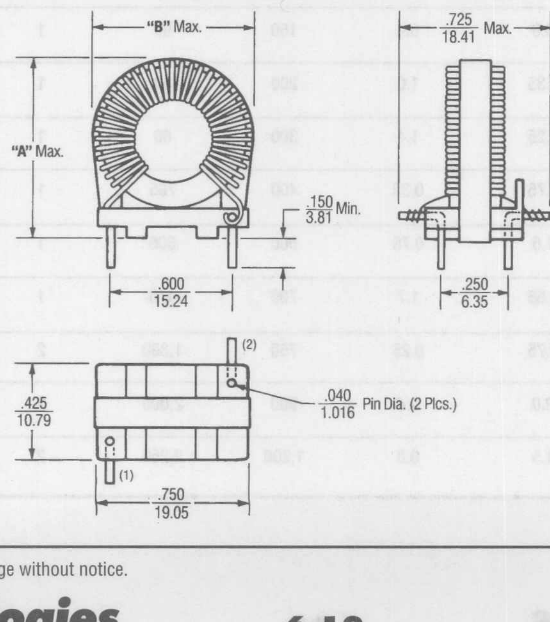
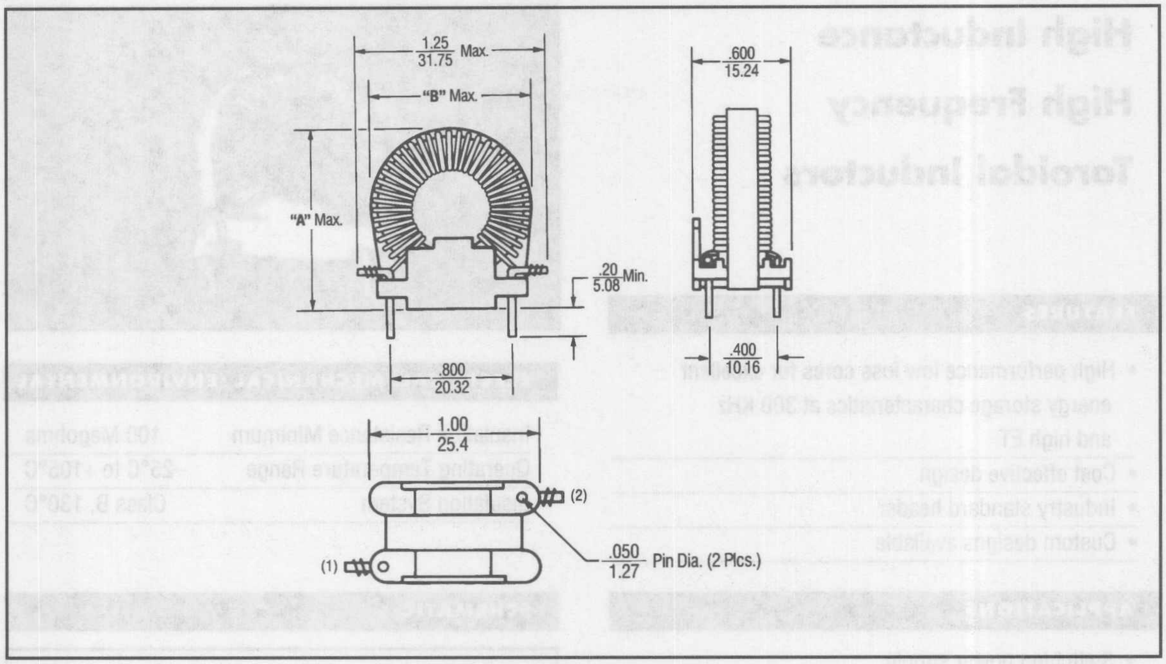


FIGURE 1 (Inch/mm)



Specifications subject to change without notice.

FIGURE 2 (Inch/mm)



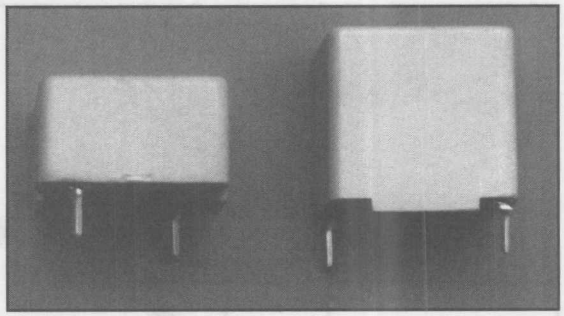
SPECIFICATIONS

Model	Inductance Typical (µH)	Current DCI Max. (Amps)	DCR Max. (Ohms)	ET_{op} (V-µSec)	Energy Storage (µJ) Min.	Fig.	Mechanical Outline Dimensions: inches/mm A	B
HM13-05001	500	0.6	0.4	150	90	1	1.15 / 29.21	.95 / 24.13
HM13-10001	1,000	0.35	1.0	200	60	1	1.15 / 29.21	.95 / 24.13
HM13-20001	2,000	0.25	1.4	300	60	1	1.15 / 29.21	.95 / 24.13
HM13-05002	500	1.75	0.35	400	765	1	1.40 / 35.56	1.25 / 30.48
HM13-10002	1,000	1.0	0.75	500	500	1	1.40 / 35.56	1.25 / 30.48
HM13-20002	2,000	0.65	1.7	700	470	1	1.40 / 35.56	1.25 / 30.48
HM13-05003	500	2.75	0.25	750	1,890	2	1.70 / 43.18	1.49 / 36.83
HM13-10003	1,000	2.0	0.4	900	2,000	2	1.70 / 43.18	1.49 / 36.83
HM13-20003	2,000	1.5	0.8	1,200	2,250	2	1.70 / 43.18	1.49 / 36.83

MODEL SERIES HM15

Low Power Inductors

Encapsulated



FEATURES

- Standard Inductance values
- Standard packages (vertical & low profile)
- Encapsulated for product integrity
- Custom designs available

APPLICATIONS

- Switch mode power supplies
- Differential EMI filters
- Output energy storage inductors in buck and boost type converters

ELECTRICAL/MECHANICAL/ENVIRONMENTAL

Insulation Resistance Minimum	100 Megohms
Operating Temperature Range	–25°C to +105°C
Temperature Rise, Maximum	40°C

SCHEMATIC

For Figures
1 & 2

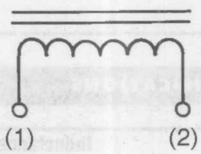
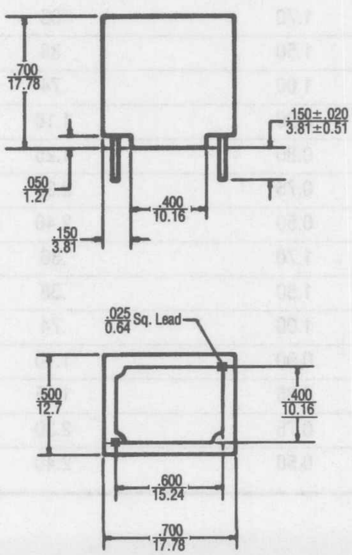
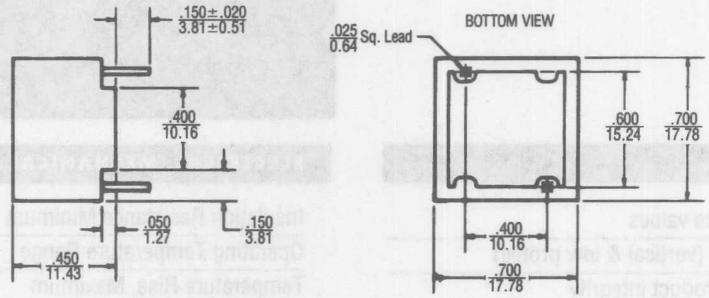


FIGURE 1 (Inch/mm)



Specifications subject to change without notice.

FIGURE 2 (Inch/mm)



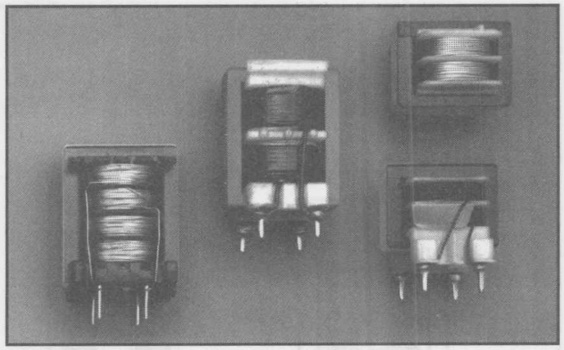
SPECIFICATIONS

Model	Inductance Typical (µH)	Max. Current @40˚C rise (Amps DC)	Resistance DC Max. (Ω)	ET_{op} (V-µSec)	Figure
HM15-10150	150	1.70	.36	80	1
HM15-10220	220	1.50	.38	90	1
HM15-10330	330	1.00	.74	100	1
HM15-10470	470	0.90	1.10	120	1
HM15-10680	680	0.85	1.25	175	1
HM15-10820	820	0.75	2.30	175	1
HM15-11000	1,000	0.50	2.40	175	1
HM15-20150	150	1.70	.36	80	2
HM15-20220	220	1.50	.38	90	2
HM15-20330	330	1.00	.74	100	2
HM15-20470	470	0.90	1.10	120	2
HM15-20680	680	0.85	1.25	175	2
HM15-20820	820	0.75	2.30	175	2
HM15-21000	1,000	0.50	2.40	175	2

MODEL SERIES HM18

Common-Mode Choke

EE Style



FEATURES

- Ferrite cores for high flux density
- Complies with UL, VDE safety requirements
- Low temperature rise
- Compact construction
- Varnish impregnation and conveyor ovens to ensure highest quality

ELECTRICAL/MECHANICAL/ENVIRONMENTAL

Voltage Rating	120/250 V Max.
Insulation Resistance Minimum	100 Megohms
Insulation System	Class B, 130°C
Temperature Rise, Maximum	40°C

APPLICATIONS

- Switching power supply
- Common mode EMI filter
- Office equipment
- Video and audio equipment

SCHEMATIC

For Figures
1, 2, 3, & 4

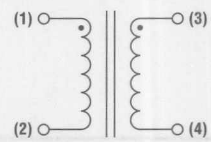


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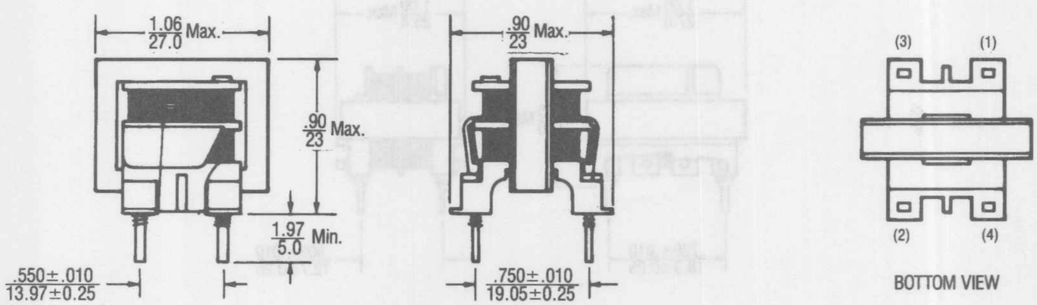
FIGURE 2 (Inch/mm)



Specifications subject to change without notice.

FIGURE 3 AND 4 (Inch/mm)

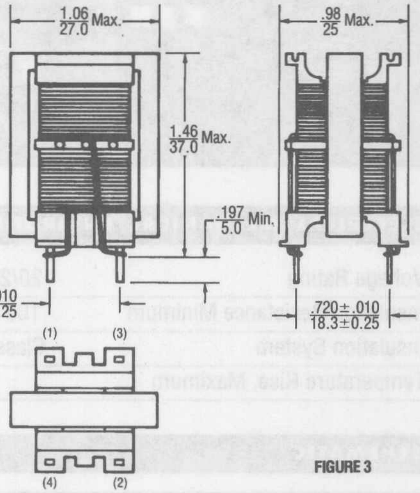


FIGURE 3

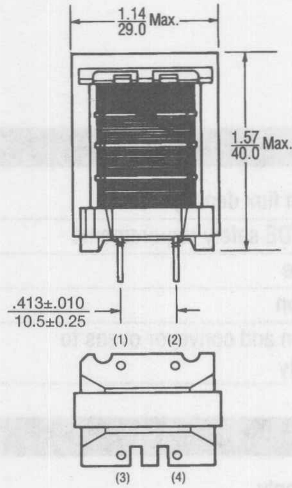
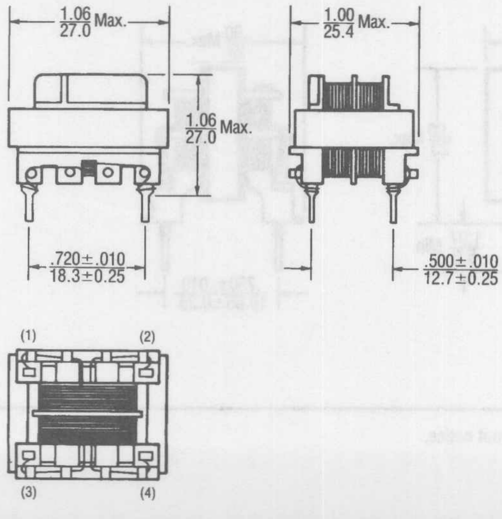


FIGURE 4

FIGURE 1 (Inch/mm)



SPECIFICATIONS

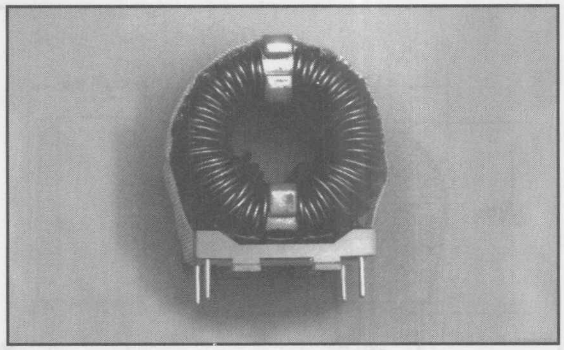
Model	Current Rating @40˚C rise (Amps)	Inductance 10KHz Min. (mH)	Resistance DC Max. (Ohms)	Wire Guage AWG (mm)*	Figure
HM18-20001	1.0	15	0.60	26 (0.40)	2
HM18-20002	1.5	8.5	0.34	25 (0.45)	2
HM18-20003	2.0	6.2	0.24	24 (0.51)	2
HM18-20004	2.5	3.9	0.15	23 (0.57)	2
HM18-20005	3.0	2.2	0.09	22 (0.64)	2
HM18-10001	1.0	15	0.60	26 (0.40)	1
HM18-10002	1.5	8.5	0.34	25 (0.45)	1
HM18-10003	2.0	6.2	0.24	24 (0.51)	1
HM18-10004	2.5	3.9	0.15	23 (0.57)	1
HM18-10005	3.0	2.2	0.09	22 (0.64)	1
HM18-30001	2.0	20	0.85	24 (0.51)	3
HM18-30002	2.5	12	0.30	23 (0.57)	3
HM18-30003	3.0	9.0	0.21	22 (0.64)	3
HM18-30004	3.5	5.0	0.13	21 (0.72)	3
HM18-30005	4.0	2.5	0.07	20 (0.81)	3
HM18-40001	2.0	14	0.60	24 (0.51)	4
HM18-40002	2.5	7.0	0.25	23 (0.57)	4
HM18-40003	3.0	6.2	0.15	22 (0.64)	4
HM18-40004	3.5	3.3	0.09	21 (0.72)	4
HM18-40005	4.0	1.7	0.05	20 (0.81)	4

* Nom. bare wire diameter

MODEL SERIES HM19

Common-Mode Choke

Toroid Style



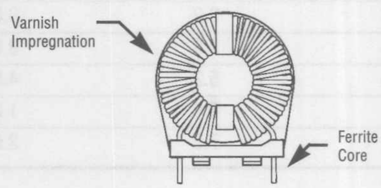
FEATURES

- Ferrite cores for high flux density
- Complies with UL, VDE safety requirements
- Low temperature rise
- Compact construction
- Varnish impregnation and conveyor ovens to ensure highest quality
- Custom designs available

APPLICATIONS

- Switching power supply
- Common mode EMI filter
- Office equipment
- Video and audio equipment

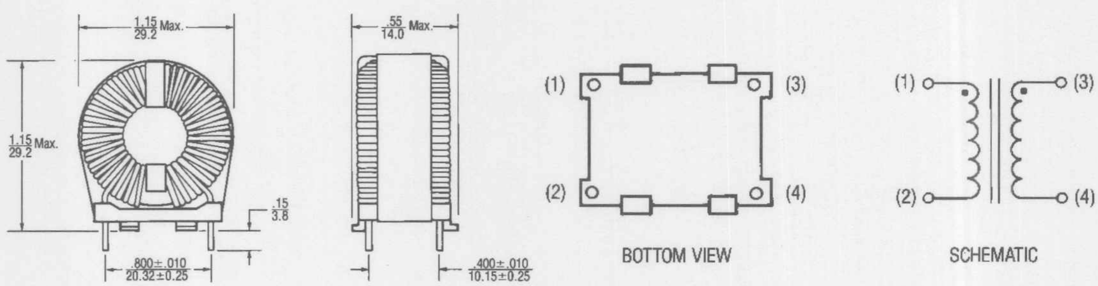
CONSTRUCTION



ELECTRICAL/ENVIRONMENTAL

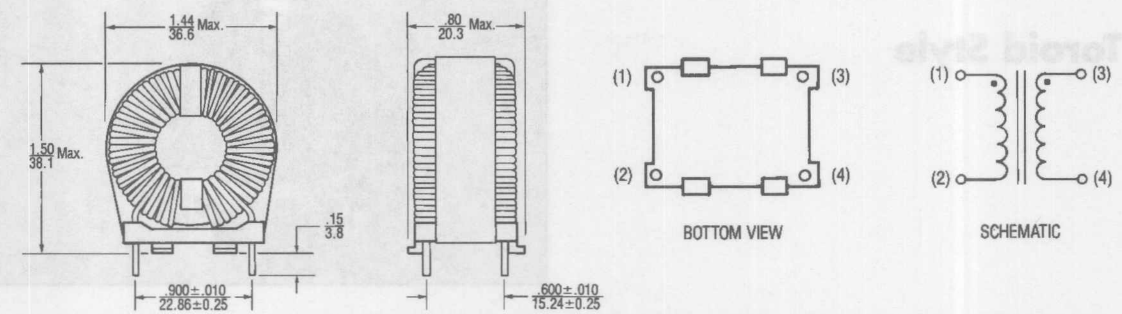
Voltage Rating	120/250 V Max.
Insulation Resistance Minimum	100 Megohms
Insulation System	Class B, 130°C
Temperature Rise, Maximum	40°C

FIGURE 1 (Inch/mm)



Specifications subject to change without notice.

FIGURE 2 (Inch/mm)



SPECIFICATIONS

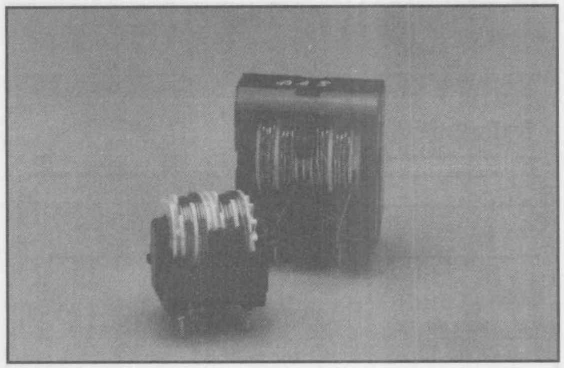
Model	Current Rating @40˚C rise (Amps)	Inductance 1KHz Min (mH)	Resistance DC Max. (Ohms)	Wire Guage AWG (mm)*	Figure
HM19-12010	1.8	10.0	.240	22(0.65)	1
HM19-11816	2.6	16.0	.160	18(1.02)	2
HM19-11808	3.2	8.0	.120	19(1.02)	2
HM19-12003	3.5	3.0	.060	20(0.81)	1
HM19-11904	5.2	4.0	.040	19(0.91)	2
HM19-11901	6.0	1.0	.020	19(0.91)	1
HM19-11702	7.5	2.0	.020	17(1.15)	2

• Nom. bare wire diameter

MODEL HM28

Common-Mode Choke

Buckle Style Core



OUTSTANDING FEATURES

- Compact size, large inductance
- Excellent frequency characteristic
- Low magnetic flux leakage
- Complies with UL, VDE safety requirements

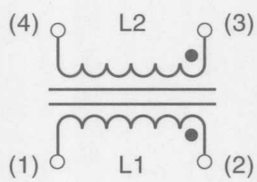
APPLICATIONS

- Switching power supplies
- Video and audio equipment
- Office equipment
- Communications equipment and other electronic devices

ELECTRICAL/ENVIRONMENTAL

Voltage Rating	120/250 V Max.
Insulation Resistance, Minimum	100 Megohm
Insulation System	Class B, 130°C
Temperature Rise, Maximum	40°C

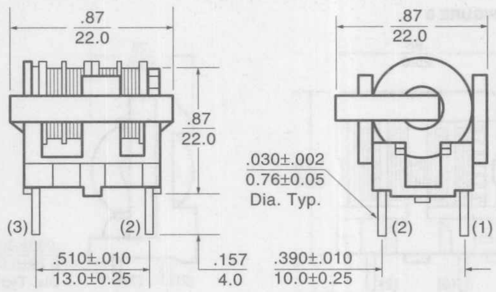
SCHEMATIC



Specifications subject to change without notice.

OUTLINE DIMENSIONS (Inch/mm)

FIGURE 1



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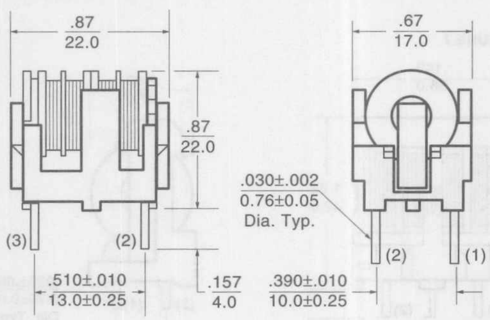
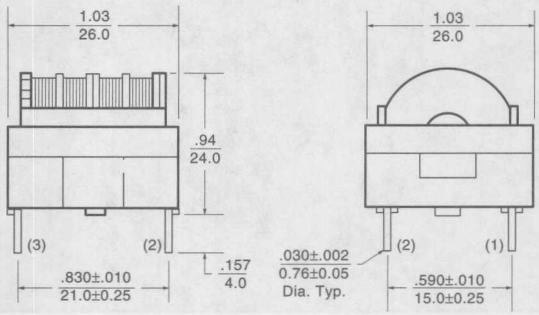
OUTLINE DIMENSIONS (Inch/mm)

FIGURE 2



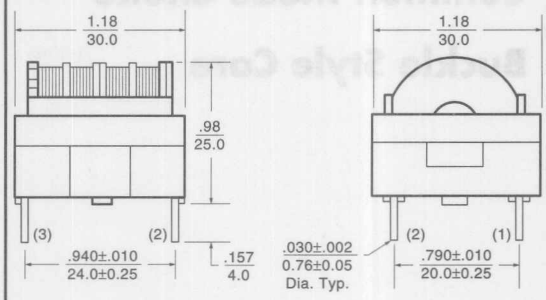
OUTLINE DIMENSIONS (Inch/mm)

FIGURE 3



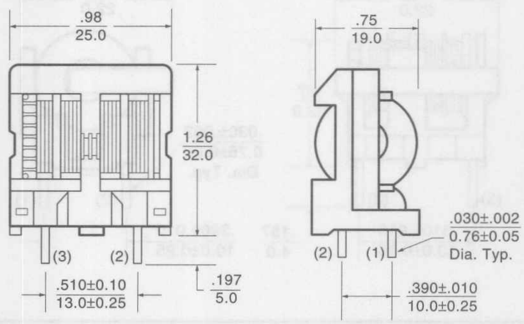
OUTLINE DIMENSIONS (Inch/mm)

FIGURE 4



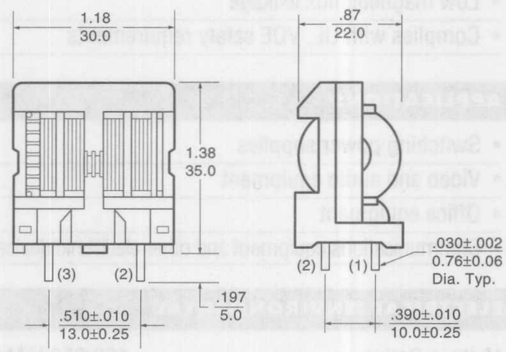
OUTLINE DIMENSIONS (Inch/mm)

FIGURE 5



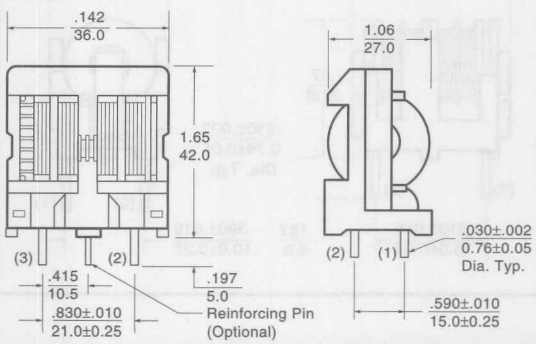
OUTLINE DIMENSIONS (Inch/mm)

FIGURE 6



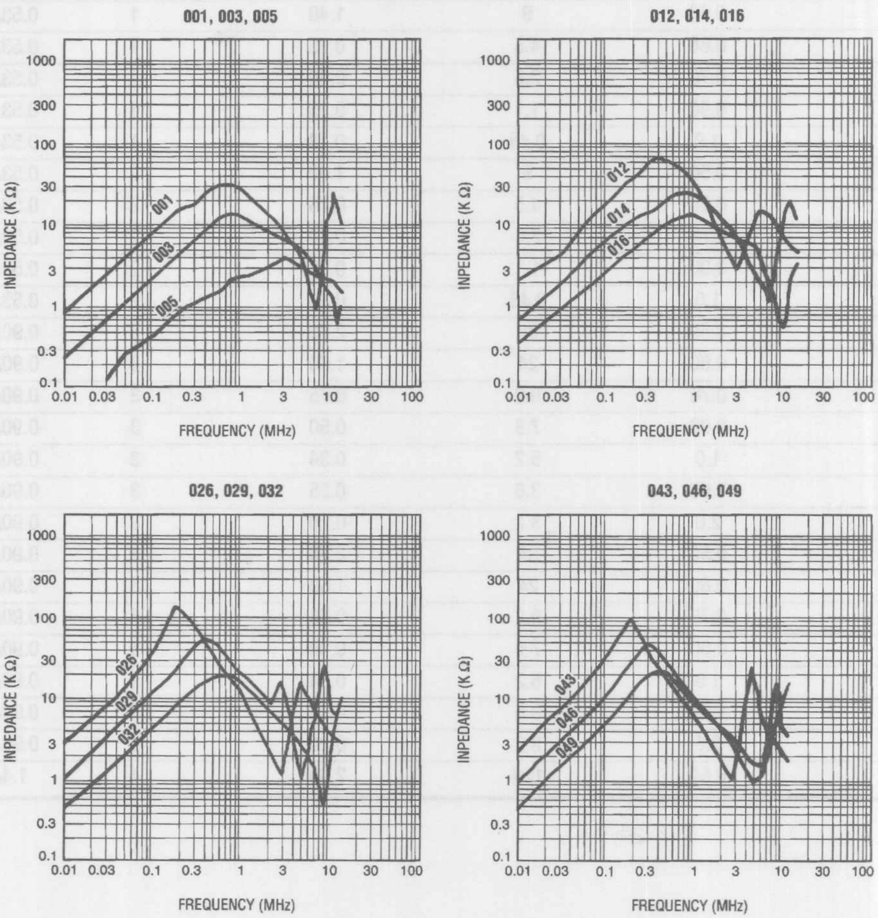
OUTLINE DIMENSIONS (Inch/mm)

FIGURE 7



PERFORMANCE

Impedance vs. Frequency



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SPECIFICATIONS

Model	Current Rating (Amps AC)	Inductance at 1.0 KHz Min. (mH)	Resistance Max. (Ohms)	Fig.	Weight (Oz./Gm)
HM28-20001	0.50	9	1.40	1	0.53/15
HM28-20002	0.60	4.5	0.75	1	0.53/15
HM28-20003	0.70	2.5	0.40	1	0.53/15
HM28-20004	0.90	1.1	0.25	1	0.53/15
HM28-20005	1.0	0.45	0.13	1	0.53/15
HM28-24006	0.50	9	1.40	2	0.53/15
HM28-24007	0.60	4.5	0.75	2	0.53/15
HM28-24008	0.70	2.5	0.40	2	0.53/15
HM28-24009	0.90	1.1	0.25	2	0.53/15
HM28-24010	1.0	0.45	0.13	2	0.53/15
HM28-24011	0.50	36	2.70	3	0.90/25
HM28-24012	0.60	24	1.60	3	0.90/25
HM28-24013	0.70	9.2	0.75	3	0.90/25
HM28-24014	0.90	7.8	0.50	3	0.90/25
HM28-24015	1.0	5.2	0.34	3	0.90/25
HM28-24016	1.50	3.6	0.25	3	0.90/25
HM28-24017	2.0	3.2	0.20	3	0.90/25
HM28-32018	0.50	36	2.70	5	0.90/25
HM28-32019	0.60	24	1.60	5	0.90/25
HM28-32020	0.70	9.2	0.75	5	0.90/25
HM28-32021	0.90	7.8	0.50	5	0.90/25
HM28-32022	1.0	5.2	0.34	5	0.90/25
HM28-32023	1.50	3.6	0.25	5	0.90/25
HM28-32024	2.0	3.2	0.20	5	0.90/25
HM28-25025	0.50	120	2.60	4	1.4/40

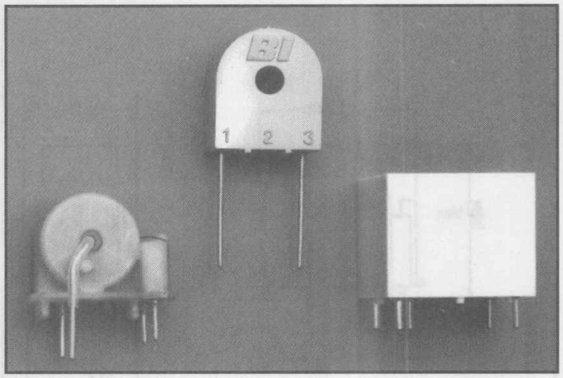
SPECIFICATIONS

Model	Current Rating (Amps AC)	Inductance at 1.0 KHz Min. (mH)	Resistance Max. (Ohms)	Fig.	Weight (Oz./Gm)
HM28-25026	0.60	92	2.0	4	1.4/40
HM28-25027	0.70	66	1.50	4	1.4/40
HM28-25028	0.90	36	0.80	4	1.4/40
HM28-25029	1.0	25	0.60	4	1.4/40
HM28-25030	1.50	15.5	0.32	4	1.4/40
HM28-25031	2.0	10	0.25	4	1.4/40
HM28-25032	2.50	8	0.19	4	1.4/40
HM28-25033	3.0	5	0.10	4	1.4/40
HM28-35034	0.50	120	2.60	6	1.4/40
HM28-35035	0.60	92	2.0	6	1.4/40
HM28-35036	0.70	66	1.50	6	1.4/40
HM28-35037	0.90	36	0.80	6	1.4/40
HM28-35038	1.0	25	0.60	6	1.4/40
HM28-35039	1.50	15.5	0.32	6	1.4/40
HM28-35040	2.0	10	0.25	6	1.4/40
HM28-35041	2.50	8	0.19	6	1.4/40
HM28-35042	3.0	5	0.10	6	1.4/40
HM28-42051	1.50	33	0.50	7	2.7/76
HM28-42052	1.80	22	0.40	7	2.7/76
HM28-42053	2.0	18	0.30	7	2.7/76
HM28-42054	2.50	12	0.20	7	2.7/76
HM28-42055	2.70	10	0.15	7	2.7/76
HM28-42056	3.0	8.1	0.12	7	2.7/76
HM28-42057	3.50	6	0.10	7	2.7/76
HM28-42058	4.0	4.7	0.08	7	2.7/76

MODEL SERIES HM31

Current Sense Transformer

Encapsulated



FEATURES

- Complies with VDE safety agency requirements
- Excellent temperature characteristics
- Encapsulating technique used to ensure long term reliability
- Excellent linearity (current vs. output voltage)
- Custom designs available

APPLICATIONS

- Switching power supply
- Designed to detect AC current and to supply the output for control circuitry
- Appliances
- Medical equipment
- Office equipment

ELECTRICAL/ENVIRONMENTAL

Insulation Resistance Minimum	100 Megohms
Operating Temperature Range	–25°C to +105°C
Dielectric Withstanding Voltage	4.2 KV Pri to Sec

Specifications subject to change without notice.

FIGURE 1 (Inch/mm)

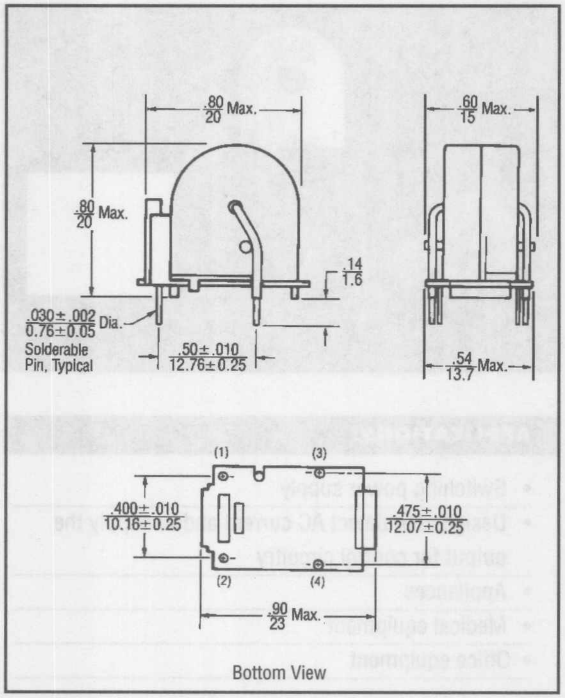


FIGURE 2 (Inch/mm)

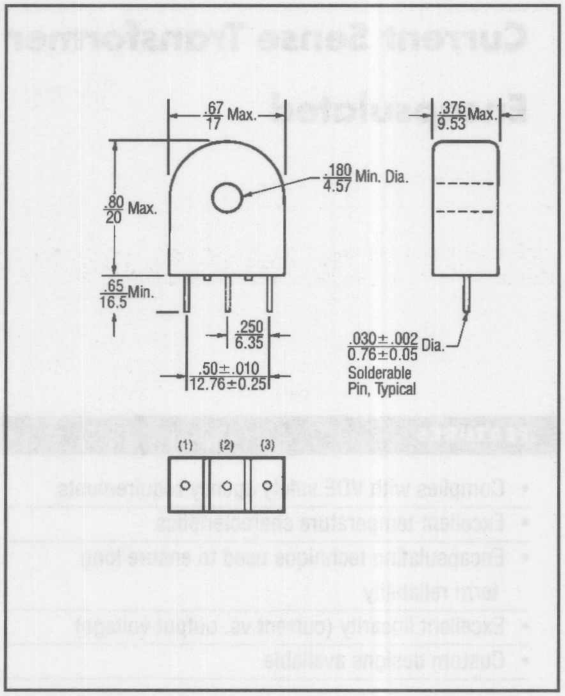
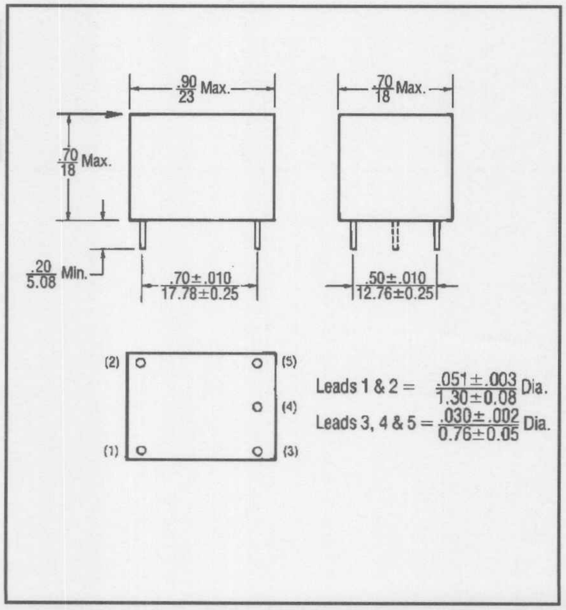


FIGURE 3 (Inch/mm)



SCHEMATICS

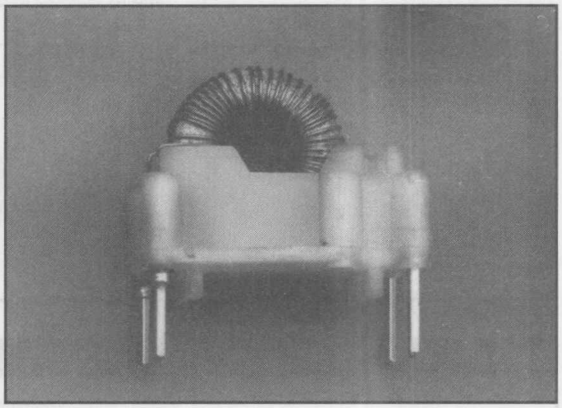
SCHEMATIC A SCHEMATIC B SCHEMATIC C SCHEMATIC D

SPECIFICATIONS

Model	Turns Ratio±1% (or ±1 turn whichever is greater)	Secondary Inductance @ 10 KHz (mH min.)	Secondary DC Resistance (Ohms) Max.	Schematic	Fig.	Secondary (V-μS) max.	Current (Amp) 1 Turn Primary
HM31-10050	1:50	5	0.7	A	1	300	5
HM31-10100	1:100	20	1.4	A	1	600	5
HM31-20050	1:50	5	0.7	B	2	330	20
HM31-20100	1:100	20	1.4	B	2	660	20
HM31-20200	1:200	85	4.5	B	2	1,300	20
HM31-21050	1:25:25	1.3	0.5	C	2	150	20
HM31-21100	1:50:50	5	0.7	C	2	330	20
HM31-21200	1:100:100	20	1.4	C	2	660	20
HM31-30050	1:50	5	0.7	A	3	330	20
HM31-30100	1:100	20	1.4	A	3	660	20
HM31-30200	1:200	85	4.5	A	3	1,300	20
HM31-30300	1:300	195	5.0	A	3	2,000	20
HM31-31050	1:25:25	1.3	0.5	D	3	160	20
HM31-31100	1:50:50	5	0.7	D	3	330	20
HM31-31200	1:100:100	20	1.4	D	3	660	20
HM31-31300	1:150:150	48	2.4	D	3	1,000	20

MODEL SERIES HM32

Current Sense Transformer



FEATURES

- Cost effective design
- Complies with VDE safety requirements
- Excellent temperature characteristics
- Designed for switching supply applications
- Excellent linearity (current vs. output voltage)
- Custom designs available

APPLICATIONS

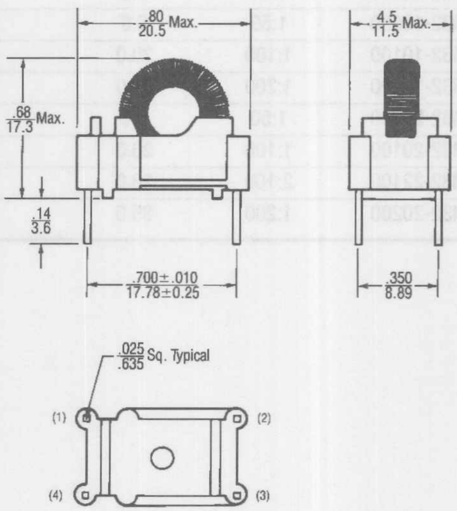
- Switching power supply
- Designed to detect AC currents and to supply the output for control circuitry
- Appliance
- Medical equipment
- Office equipment

ELECTRICAL/ENVIRONMENTAL

Insulation Resistance Minimum	100 Megohms
Operating Temperature Range	–25°C to +105°C
Insulation System	Class B, 130°C

Specifications subject to change without notice.

FIGURE 1 (Inch/mm)



SCHEMATIC

For Figures:
1, 2

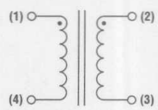
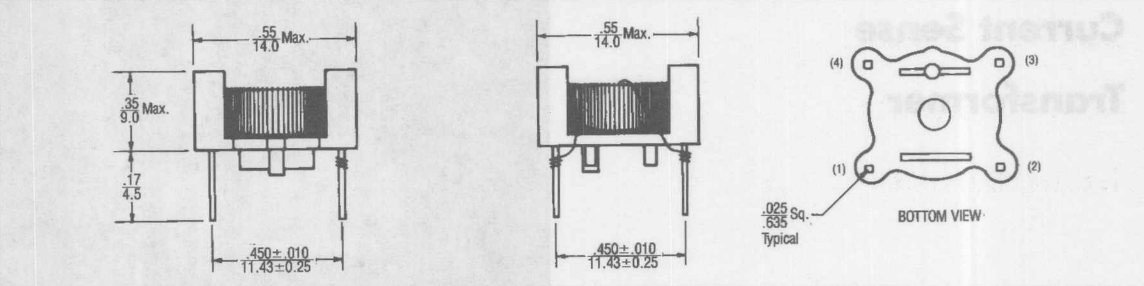


FIGURE 2 (Inch/mm)



SPECIFICATIONS

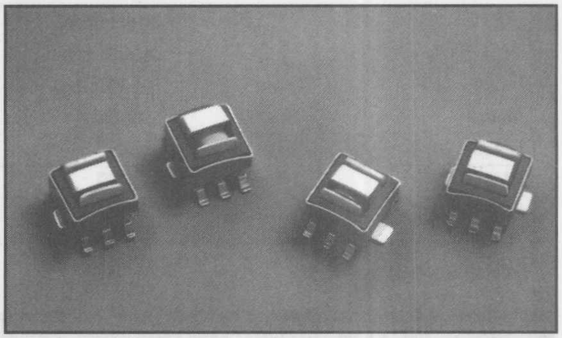
Model	Turns N1:N2	Secondary at 10KHz Inductance Min (mH)	Secondary DC Resistance (Ω) Max	Figure	Primary Maximum Amps	Core Style	Secondary (V-µS) Max.
HM32-10010	1:10	0.2	0.2	1	3	toroid	67
HM32-10050	1:50	5.0	0.7	1	3	toroid	330
HM32-10100	1:100	20.0	1.4	1	3	toroid	660
HM32-10200	1:200	85.0	4.5	1	3	toroid	1,300
HM32-20050	1:50	5.0	0.7	2	3	toroid	330
HM32-20100	1:100	20.0	1.4	2	3	toroid	660
HM32-22100	2:100	20.0	1.4	2	3	toroid	660
HM32-20200	1:200	85.0	4.5	2	3	toroid	1,300

MODEL SERIES HM33

Surface Mount

Current Sense

Transformer



FEATURES

- Surface mount design
- Compatible with surface mount process temperatures
- Designed for switching supply applications
- Optimal performance at 250 KHz and above
- Three standard turns ratios
- Custom designs available

ELECTRICAL/ENVIRONMENTAL

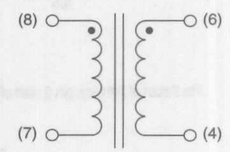
Insulation Resistance Minimum	10 Megohms
Operating Temperature Range	–25°C to +105°C
Insulation System	Class B, 130°C

Specifications subject to change without notice.

APPLICATIONS

- Switching power supply
- Design to detect AC current and to supply the output for control circuitry
- Appliance
- Medical equipment
- Office equipment

SCHEMATIC



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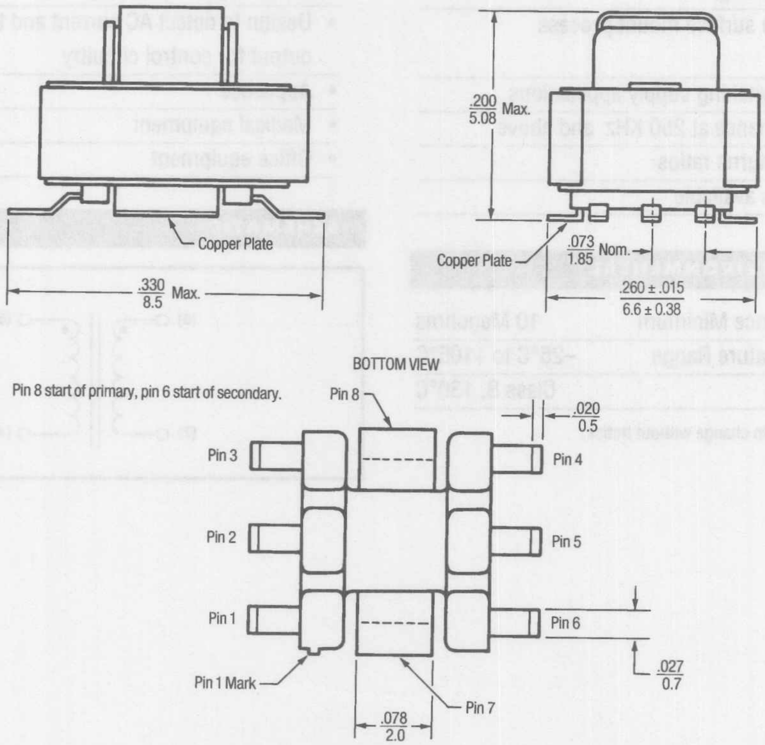
SPECIFICATIONS

Model	Turns N1:N2	Secondary Inductance at 10KHz (µH Min)	Secondary DC Resistance (Ω) Max	Primary Maximum Amps	Color Code
HM33-10070	1:70	980	4.75	6	Yellow
HM33-10040	1:40	320	1.35	6	Blue
HM33-10030	1:30	180	1.0	6	Red

Electrical Specification at 25°C.

OUTLINE DIMENSIONS (Inch/mm)

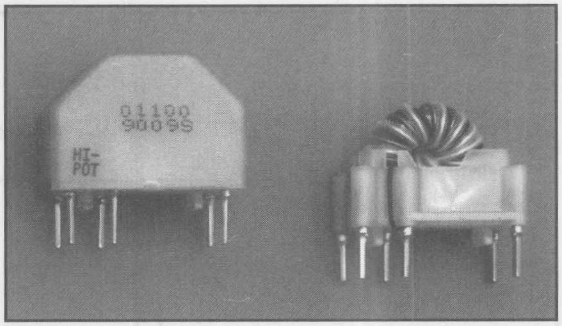


MODEL SERIES HM41

Gate Drive Transformer

Toroid Style

with Mounting Bracket



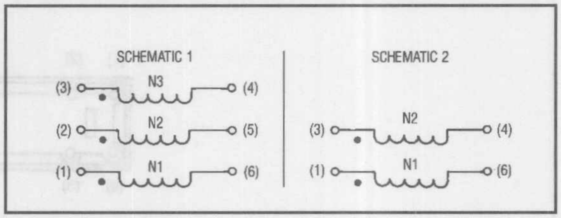
APPLICATIONS

- Switching power supply
- Motor control circuit
- Office equipment
- CRT display

FEATURES

- Complies with VDE safety requirements
- Custom designs available

SCHEMATICS



ELECTRICAL/ENVIRONMENTAL

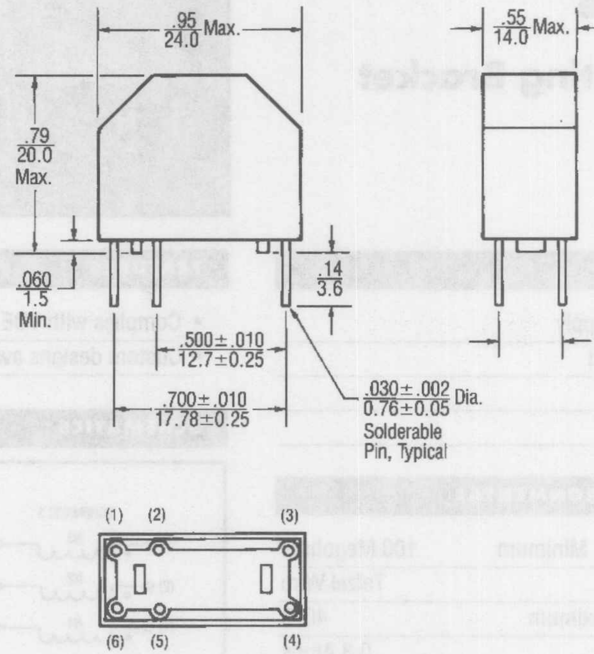
Insulation Resistance, Minimum	100 Megohms
Insulation System	Tefzel Wire
Temperature Rise, Maximum	40°C
Current Rating	0.3 Amps

SPECIFICATIONS

Model	Turns ±0 N1:N2:N3	Inductance 1V rms 10KHz Term 1-6 mH(Min.)	Leakage* Inductance Term 3-4 µH(Max.)	DCR Term 1-6 Ohms(Max.)	DCR Term 3-4 Ohms(Max.)	ET Term 1-6 V-µS(Max.)	Schematic
HM41-10812	8:8:12	0.138	0.3	0.060	0.097	52	1
HM41-21010	10:10	0.216	0.3	0.064	0.064	65	2
HM41-11010	10:10:10	0.216	0.3	0.064	0.064	65	1
HM41-11210	12:12:10	0.310	0.3	0.077	0.072	78	1
HM41-11410	14:14:10	0.420	0.3	0.090	0.072	91	1
HM41-20105	10:15	0.216	0.3	0.064	0.100	65	2
HM41-11510	15:15:10	0.480	0.3	0.100	0.072	98	1
HM41-12010	20:20:10	0.860	0.3	0.138	0.072	130	1
HM41-12020	20:20:20	0.860	0.3	0.156	0.156	130	1

Specifications subject to change without notice.
Electric Specifications at 25°C
*Measured with Primary Shorted

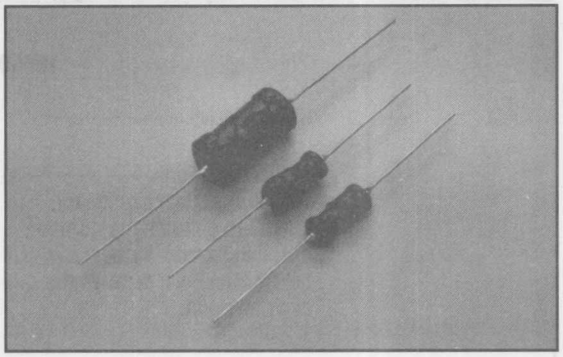
OUTLINE DIMENSIONS (Inch/mm)



MODEL

HM50 & HM51

Miniature Power Inductors



APPLICATIONS

- **Designed for use with:**
  Linear Technology models LT1073, LT1173
  National Semiconductor model LM2574
  Unitrode model UC2575
- Buck or boost, DC to DC power conversion
- SCR and triac controls
- EMI suppression
- Output ripple current filters

OUTSTANDING FEATURES

- Low DCR, high current
- High saturation flux density, optimum current handling capability
- Low cost
- Small size axial leads
- Low temperature rise
- Wound ferrite design, insulated with pvc sleeve

ELECTRICAL/ENVIRONMENTAL

Inductance Range	3.9μH to 10,000μH (up to 18,000μH on HM 50)
Standard Tolerance	±10%
Operating Temperature Range	-55°C to +105°C
Insulation System	Class B, 130°C

Specifications subject to change without notice.

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ORDERING INFORMATION

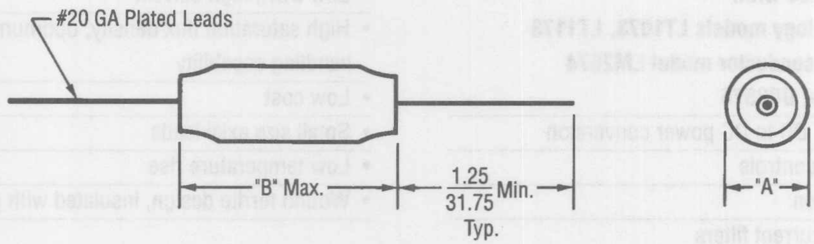
HM50 330 K

Model Series — HM50

Inductance Code — 330
First 2 digits are significant.
Last digit denotes the number
of trailing zeros. Values
below 10µH, "R" denotes the
decimal point.

Inductance Tolerance — K
J = 5%
K = 10%
M = 20%

OUTLINE DIMENSIONS (Inch/mm)



Model Series	"A" (in/mm)	"B" (in/mm)
HM50	.26/6.6	.63/16.0
HM51	.46/11.7	1.0/25.4

SPECIFICATIONS

Model	Inductance Nominal (µH) ±10% (Note 1)	Resistance DCR, Max. (Ohms)	Rated IDC (Amps) (Note 2)	INCR IDC (Amps) (Note 3)
HM50-3R9K	3.9	.019	3.60	7.30
HM50-4R7K	4.7	.022	3.40	6.30
HM50-5R6K	5.6	.024	3.20	5.60
HM50-6R8K	6.8	.026	3.10	5.30
HM50-8R2K	8.2	.028	3.00	4.50
HM50-100K	10	.033	2.80	4.10
HM50-120K	12	.037	2.60	3.60
HM50-150K	15	.040	2.50	3.30
HM50-180K	18	.044	2.40	3.00
HM50-220K	22	.050	2.23	2.70
HM50-270K	27	.056	2.10	2.50
HM50-330K	33	.076	1.81	2.20
HM50-390K	39	.094	1.63	2.00
HM50-470K	47	.109	1.51	1.80
HM50-560K	56	.140	1.33	1.70
HM50-680K	68	.131	1.31	1.50
HM50-820K	82	.152	1.30	1.40
HM50-101K	100	.208	1.10	1.20
HM50-121K	120	.283	0.94	1.10
HM50-151K	150	.340	0.86	1.00
HM50-181K	180	.362	0.83	0.95
HM50-221K	220	.430	0.76	0.86
HM50-271K	270	.557	0.67	0.77
HM50-331K	330	.665	0.61	0.70
HM50-391K	390	.772	0.57	0.64
HM50-471K	470	1.15	0.47	0.59
HM50-561K	560	1.27	0.44	0.54
HM50-681K	680	1.61	0.40	0.49
HM50-821K	820	1.96	0.36	0.44
HM50-102K	1000	2.30	0.33	0.40
HM50-122K	1200	2.65	0.30	0.35
HM50-152K	1500	3.45	0.27	0.33
HM50-182K	1800	4.03	0.25	0.29
HM50-222K	2200	4.48	0.23	0.27
HM50-272K	2700	5.40	0.21	0.24
HM50-332K	3300	6.56	0.20	0.22
HM50-392K	3900	8.63	0.17	0.20
HM50-472K	4700	9.66	0.16	0.18
HM50-562K	5600	13.9	0.13	.166
HM50-682K	6800	16.3	0.12	.151
HM50-822K	8200	20.8	0.11	.136
HM50-103K	10000	26.4	0.10	.125
HM50-123K	12000	29.9	0.09	.114

Notes: 1. Inductance measured at 1KHz without DC current.
2. The rated DC current is based on an approimate 20°C termperature rise.
3. The incremental current (INCR I) is the approximate current at which the inductance will be decreased by 5% from its initial (zero DC) value due to saturation.

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SPECIFICATIONS (CONT'D)

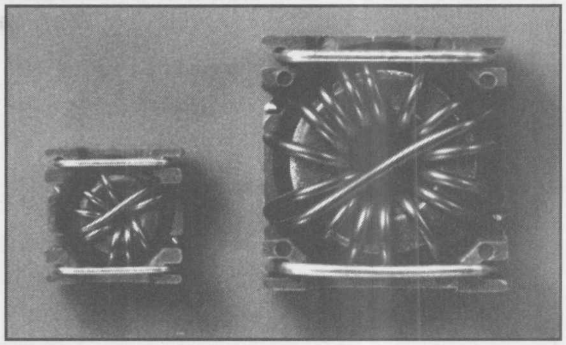
Model	Inductance Nominal (µH) ±10% (Note 1)	Resistance DCR, Max. (Ohms)	Rated IDC (Amps) (Note 2)	INCR IDC (Amps) (Note 3)
HM50-153K	15000	42.5	0.08	.098
HM50-183K	18000	48.3	0.07	.091
HM51-3R9K	3.9	.007	8.40	15.5
HM51-4R7K	4.7	.008	7.90	13.9
HM51-5R6K	5.6	.011	6.70	12.6
HM51-6R8K	6.8	.011	6.70	11.6
HM51-8R2K	8.2	.013	6.20	9.89
HM51-100K	10	.017	5.40	8.70
HM51-120K	12	.019	5.10	8.21
HM51-150K	15	.022	4.70	7.34
HM51-180K	18	.023	4.70	6.64
HM51-220K	22	.026	4.40	6.07
HM51-270K	27	.027	4.30	5.36
HM51-330K	33	.032	4.00	4.82
HM51-390K	39	.033	3.90	4.36
HM51-470K	47	.035	3.80	3.98
HM51-560K	56	.037	3.70	3.66
HM51-680K	68	.047	3.30	3.31
HM51-820K	82	.060	2.90	3.10
HM51-101K	100	.090	2.30	2.79
HM51-121K	120	.113	2.10	2.54
HM51-151K	150	.129	2.00	2.22
HM51-181K	180	.150	1.80	1.98
HM51-221K	220	.162	1.76	1.89
HM51-271K	270	.208	1.55	1.63
HM51-331K	330	.212	1.53	1.51
HM51-391K	390	.281	1.33	1.39
HM51-471K	470	.380	1.15	1.24
HM51-561K	560	.420	1.10	1.17
HM51-681K	680	.548	0.96	1.05
HM51-821K	820	.655	0.87	0.97
HM51-102K	1,000	.844	0.77	0.87
HM51-122K	1,200	1.04	0.70	0.79
HM51-152K	1,500	1.18	0.65	0.70
HM51-182K	1,800	1.56	0.57	0.64
HM51-222K	2,200	2.00	0.50	0.58
HM51-272K	2,700	2.06	0.50	0.53
HM51-332K	3,300	2.63	0.44	0.47
HM51-392K	3,900	2.75	0.43	0.43
HM51-472K	4,700	3.19	0.40	0.39
HM51-562K	5,600	3.92	0.36	0.359
HM51-682K	6,800	5.69	0.30	0.322
HM51-822K	8,200	6.32	0.28	0.293
HM51-103K	10,000	7.30	0.26	0.266

Notes: 1. Inductance measured at 1KHz without DC current.
2. The rated DC current is based on an approimate 20°C termperature rise.
3. The incremental current (INCR I) is the approximate current at which the inductance will be decreased by 5% from its initial (zero DC) value due to saturation.

MODEL SERIES HM77

NEW PRODUCT

Surface Mount Inductors



OUTSTANDING FEATURES

- High performance low core loss powder iron core for excellent high frequency application
- Low profile, designed for machine placement
- Compatible with vapor phase and infra-red reflow soldering
- Custom designs available

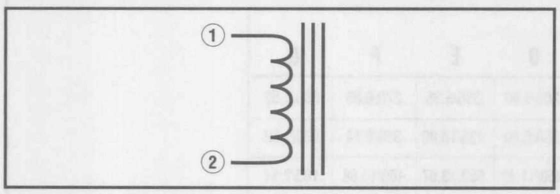
APPLICATIONS

- Lap Top or Notebook Computers
- DC / DC Converter in distributed power system
- Output Ripple Current Filter

ELECTRICAL / ENVIRONMENTAL

Insulation Resistance Minimum	100 Megohms
Operature Temperature Range	-25°C to +130°C
Insulation System	Class B, 130°C
Temperature Rise, Maximum	50°C

SCHEMATIC



Specifications subject to change without notice.

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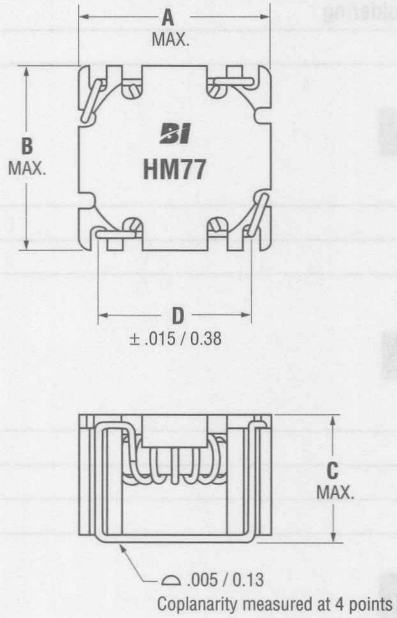
ORDERING INFORMATION

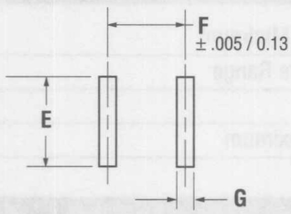
HM77 1000 1 TR

- Model Series
- Model Description
- Case Size
  - 1 = SM 1
  - 2 = SM 2
  - 3 = SM 3
  - 4 = SM 4
  - 5 = SM 5
  - 6 = SM 6
- Optional Package* Tape & Reel

* Standard packaging is Anti-Static tubes. An option of 13" tape and reel packaging can be ordered by adding a "TR" suffix to the Part Number.

OUTLINE DIMENSION (Inch/mm)





CASE SIZE	A	B	C	D	E	F	G
SM 1	.340/8.64	.340/8.64	.250/6.35	.260/6.60	.330/8.38	.270/6.86	.060/1.52
SM 2	.440/11.18	.435/11.05	.350/8.89	.350/8.89	.425/10.80	.360/9.14	.060/1.52
SM 3	.565/14.35	.560/14.22	.350/8.89	.450/11.43	.550/13.97	.460/11.68	.100/2.54
SM 4	.625/15.88	.600/15.24	.360/9.14	.500/12.70	.580/14.73	.510/12.95	.100/2.54
SM 5	.725/18.40	.585/14.90	.340/8.64	.610/15.50	.580/14.73	.610/15.50	.100/2.54
SM 6	.805/20.40	.690/17.53	.420/10.67	.680/17.27	.690/17.53	.690/17.53	.100/2.54

SPECIFICATIONS

	OPERATING VALUES			CONTROL VALUES (NOTE 3)			
PART NUMBER	L_{DC} MH (NOTE 1)	I_{DC} AMPS	E TOP V-MS (NOTE 2)	CASE SIZE	L W/O DC L_O MH ± 20%	NOMINAL DCR M OHMS	MAXIMUM DCR M OHMS
HM77 - 10001	1.01	3.40	0.532	SM 1	1.10	11.00	12.50
HM77 - 20001	6.20	1.40	1.33	SM 1	7.00	60.30	70.00
HM77 - 30001	17.60	1.00	2.40	SM 1	22.70	109.00	125.00
HM77 - 40002	3.80	4.80	1.76	SM 2	5.20	14.80	17.30
HM77 - 50002	9.40	2.80	2.70	SM 2	12.30	37.80	43.40
HM77 - 60002	29.70	1.40	4.60	SM 2	35.30	141.00	166.00
HM77 - 70002	114.00	0.94	10.00	SM 2	167.00	330.00	380.00
HM77 - 80003	2.50	8.00	1.77	SM 3	3.80	7.20	8.30
HM77 - 90003	5.10	5.40	2.51	SM 3	7.50	14.30	17.70
HM77 - 10003	16.20	2.70	4.29	SM 3	21.90	54.70	63.00
HM77 - 11003	58.10	1.30	7.83	SM 3	73.00	233.00	290.00
HM77 - 12003	192.00	0.90	15.70	SM 3	292.00	472.00	560.00
HM77 - 13003	383.00	0.72	23.50	SM 3	672.00	750.00	862.00
HM77 - 14004	0.91	13.30	1.035	SM 4	1.25	4.56	5.70
HM77 - 15004	1.32	11.50	1.33	SM 4	2.10	4.56	5.70
HM77 - 16004	4.90	7.80	3.04	SM 4	7.90	10.50	12.40
HM77 - 17004	9.00	5.50	4.06	SM 4	14.00	19.30	22.30
HM77 - 18004	29.10	2.70	6.90	SM 4	40.50	75.80	85.00
HM77 - 19004	645.00	0.74	36.50	SM 4	1134.00	1040.00	1250.00
HM77 - 20005	1.75	10.90	1.83	SM 5	2.80	5.68	6.90
HM77 - 21005	2.50	11.40	2.23	SM 5	4.20	6.19	7.50
HM77 - 22006	2.03	13.00	3.30	SM 6	2.70	5.60	6.80
HM77 - 23006	3.50	12.40	3.13	SM 6	6.50	5.75	6.60
HM77 - 24006	4.70	10.40	3.58	SM 6	8.40	7.18	8.30
HM77 - 25006	9.30	7.20	4.92	SM 6	16.00	16.30	18.70
HM77 - 26006	16.10	5.10	6.27	SM 6	25.90	30.30	32.00
HM77 - 27006	50.00	2.60	10.50	SM 6	72.90	115.00	130.00
HM77 - 28006	1070.00	0.710	54.40	SM 6	1950.00	1480.00	1700.00

Notes:

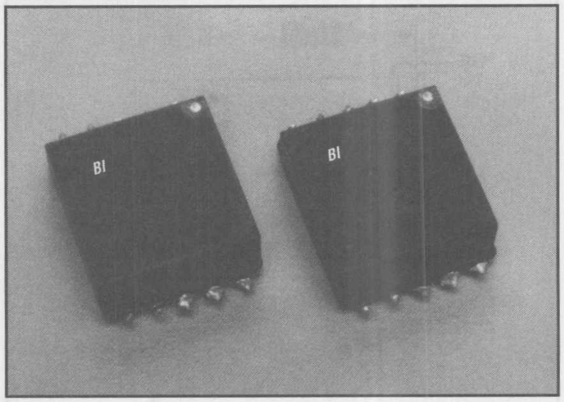
(1) Inductance values are rated for an operating temperature range of -25°C to +130°C with rated DC current flowing and the operating ETop across the inductor.
(2) ETop is the product of Ripple Voltage and the operating frequency is in Volt-Microseconds.
(3) The control values of inductance are measured at the operating Flux Density equal or less than 10 Gauss and without DC current.

MODEL HM00-93839

Low Profile

Dual-Output

Surface Mount Inductor



OUTSTANDING FEATURES

- Low profile surface mount design
- Low loss, high efficiency
- Compatible with surface mount process temperatures
- Base material meets UL 94V-O requirements
- Used in combination with Linear Technology switching regulator LTC 1149

ELECTRICAL/ENVIRONMENTAL

Insulation Resistance, Minimum	100 Megohm
Operating Temperature Range	-25°C to +105°C
Insulation System	Class B, 130°C

SPECIFICATIONS

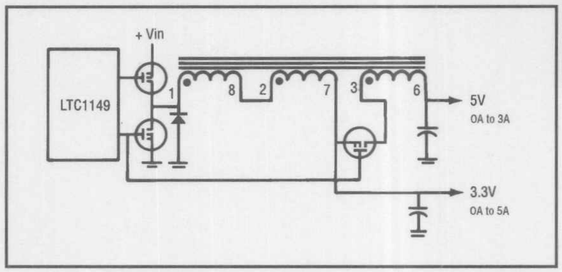
Primary Inductance at 1.0 KHz (Strap Terminals 2 & 8) (1-7)	17.4 µH ±15%
Winding DC Resistance, Maximum (1-8), (2-7), (3-6)	20m Ω
Input Voltages	8V to 24V
Output Power	Combination of 3.3V and 5V loads, totalling of 17 watts or less
Dielectric Breakdown Voltage	300V dc

Specifications subject to change without notice.

APPLICATION

Notebook Computers

TYPICAL APPLICATION DIAGRAM



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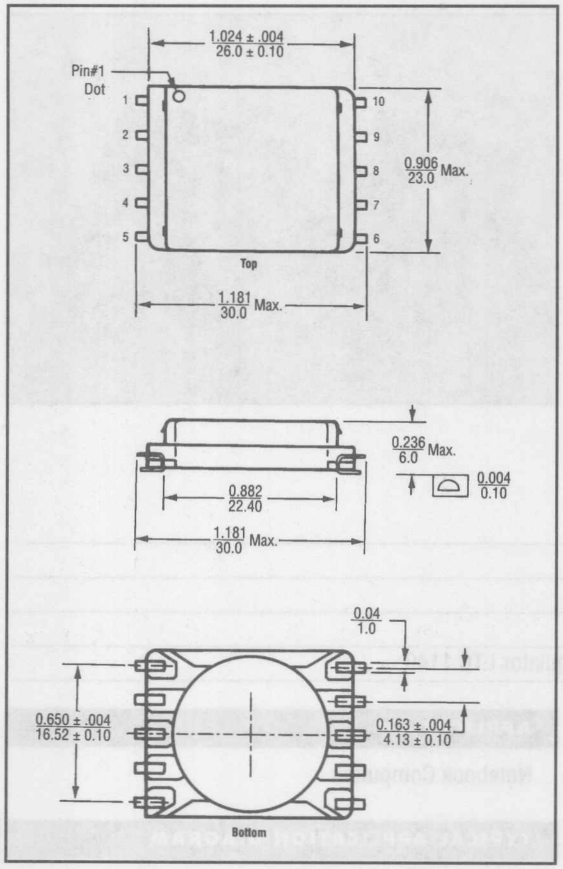
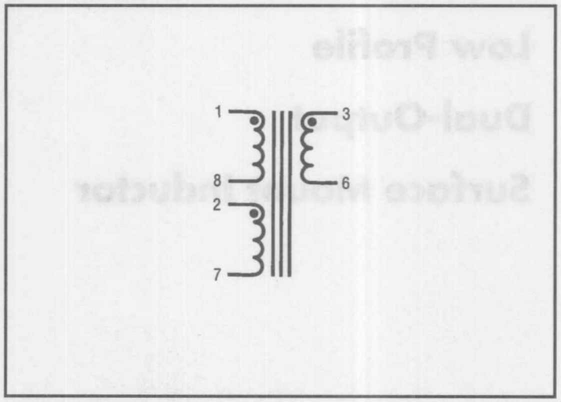
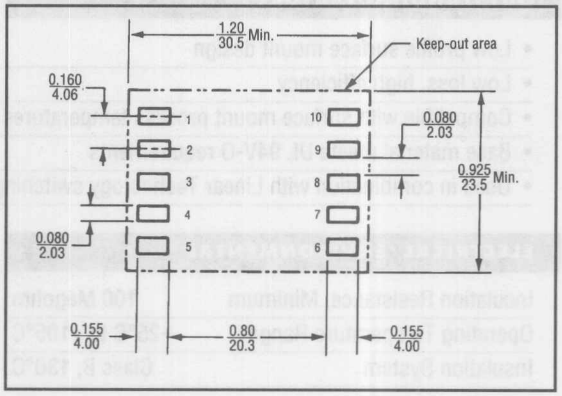
OUTLINE DIMENSIONS (Inch/mm)



SCHEMATIC



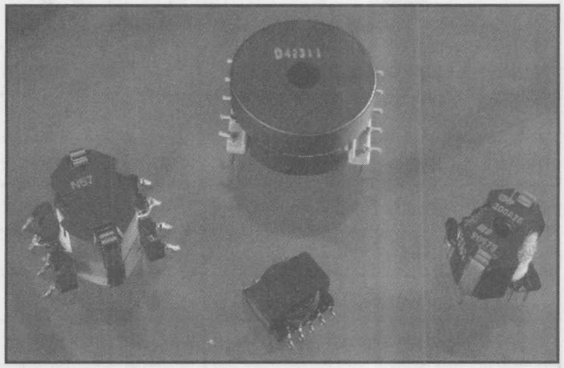
RECOMMENDED PCB LAYOUT (Inch/mm)



MODEL SERIES HM80

NEW PRODUCT

ISDN Series



OUTSTANDING FEATURES

- Excellent frequency behavior
- Isolation voltage levels available for domestic and international safety standard
- Designed to meet the CCITT 1.430 pulse waveform template and impedance mask requirements
- Matched to IC Characteristics for easy selection

APPLICATIONS

- Isolation transformers for ISDN networks, U-interface and S/ T interface
- Provides isolation for the line card and the terminal from the line

ELECTRICAL/ENVIRONMENTAL

Insulation Resistance, Minimum	100 Megohms
Operating Temperature Range	0°C to +85°C
Storage Temperature Range	-40°C to +100°C

PACKAGING

Standard:	Tubes or Tray Pack
Option:	Tape & Reel (Available for SMD devices)

ELECTRICAL SPECIFICATIONS

MODEL	I-DC MA	N	LP mH	LL µH	RP Ω	RS Ω	HIPOT V RMS	FIG
HM80 - 10001	–	1CT:1CT	22	10	2.8	2.8	1500	1
HM80 - 20014	–	1CT:1.32CT	7	17	0.9	1.5	1100	14
HM80 - 30008	30	1:0.75:0.75	12.3	27.5	6.8	12.4	1100	8
HM80 - 40010	60	1:0.3:0.3	2.7	85	4.9	3.8	500	10
HM80 - 50004	–	1CT:1.8CT	22	20	2.8	5.5	1500	4
HM80 - 60002	–	1:1:2:2	22	18	2.2	5.4	1500	2
HM80 - 70004	–	1CT:2CT	20	30	1.4	13	1500	4
HM80 - 80005	–	1CT:2CT	20	30	1.4	13	1500	5
HM80 - 90009	100	1:1:4	12.5	30	5.5	13.4	2000	9
HM80 - 10011	–	1CT:2CT	22	30	8	15	1500	11
HM80 - 11004	–	1CT:2.5CT	22	20	2.8	6.5	1500	4
HM80 - 12007	–	2.5:1:1	72	160	8.5	1.0	1100	7
HM80 - 13006	60	0.66:0.66:1	7.9	50	1.8	2.5	2000	6
HM80 - 14003	90	1.5:1.5:1:1	27	30	10.7	7.4	2000	3
HM80 - 15013	60	1.6:1.6:1:1	13.3	70	49	4.8	2000	13
HM80 - 16012	60	1:1:1CT	22.5	90	5.8	1.5	1100	12

SYMBOLS

N	Turns ratio, primaries to secondaries.
IDC	Maximum permissible DC current in the primary winding(s). The primary winding is defined as the winding at the line side.
LP	Inductance of primary winding(s) (connected in series).
LL	Leakage inductance of primary winding(s) with secondary winding(s) short circuited.
RP	Resistance of primary winding(s) (connected in series).
RS	Resistance of secondary winding(s) (connected in series).
HIPOT	Breakdown voltage between primary and secondary.

TRANSFORMER CROSS REFERENCE FOR IC CHIPS

IC PART NUMBER	IC MANUFACTURER	MODEL	INTERFACE
MC 145474 / 145475	MOTOROLA	HM80 - 10001	S/T
PEB 2091	SIEMENS	HM80 - 20007	S/T
T 7264	AT&T	HM80 - 30008	U
TP 3410	NATIONAL	HM80 - 30008	U
ST 5410	SGS THOMSON	HM80 - 30008	U
PEB 2090	SIEMENS	HM80 - 40010	U
29C53	INTEL	HM80 - 50004	S/T
PEB 2080 / 2081 / 2085 / 2086	SIEMENS	HM80 - 60002	S/T
AM 2080 / 2081 / 2085, AM 79C30A / 79C32A	AMD	HM80 - 70004	S/T
TP 3420 / 3421	NATIONAL	HM80 - 80005	S/T
ST 5420	SGS THOMSON	HM80 - 10011	S/T
MT 8930	MITEL	HM80 - 10011	S/T
MTC 2072	MIETEC	HM80 - 10011	S/T
MT 8971 / 8972	MITEL	HM80 - 90009	U
29C53	INTEL	HM80 - 11004	S/T
T 7250 / T 7252	AT&T	HM80 - 11004	S/T
T 7262 / T 7263	AT&T	HM80 - 12007	S/T
PEB 2090 / 2091	SIEMENS	HM80 - 13006	U
AM 20902 / AM 2091	AMD	HM80 - 13006	U
MTC 2071	MIETEC	HM80 - 13006	U
TP 3410	NATIONAL	HM80 - 14003	U
PEB 2090 / 2091	SIEMENS	HM80 - 15013	U
AM 20902 / 2091	AMD	HM80 - 15013	U
MC 145472	MOTOROLA	HM80 - 16012	U

OUTLINE DIMENSIONS (Inch/mm)

Figure 1

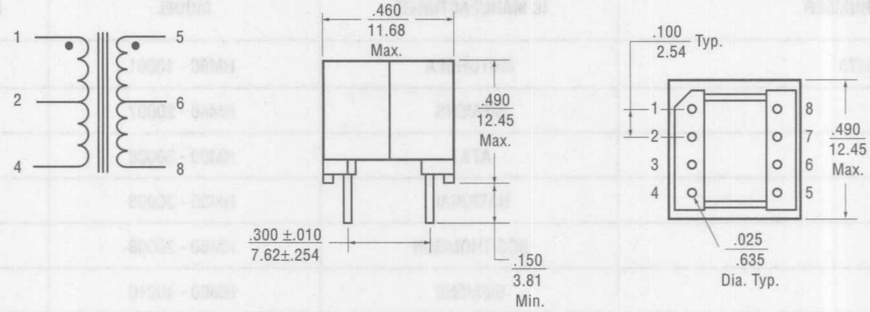


Figure 2

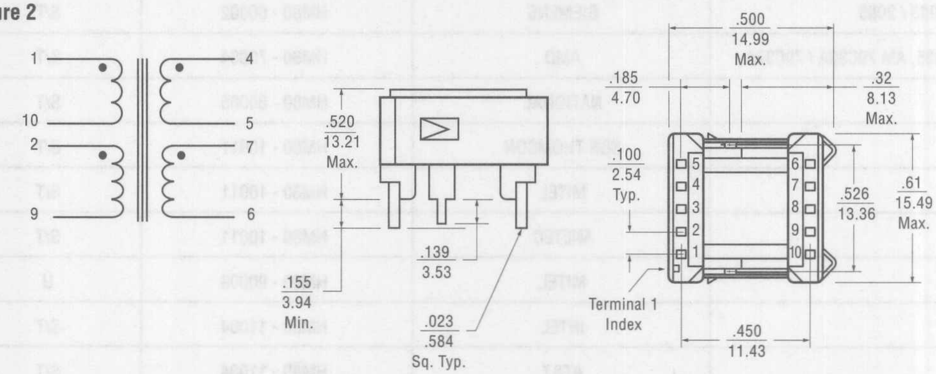
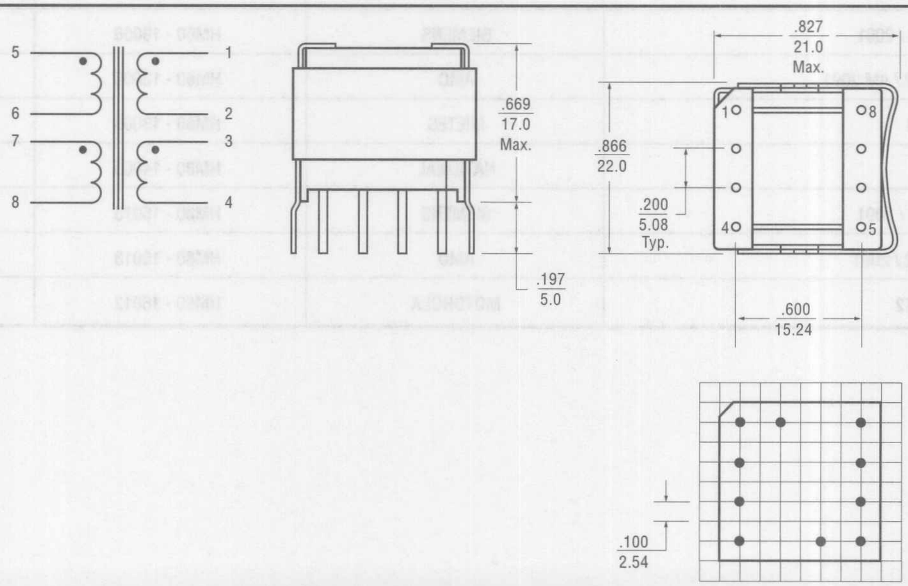


Figure 3



OUTLINE DIMENSIONS (Inch/mm)

Figure 4

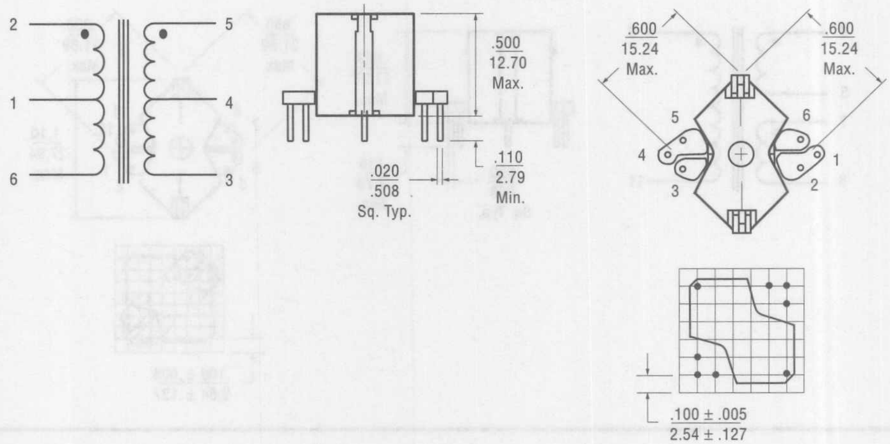
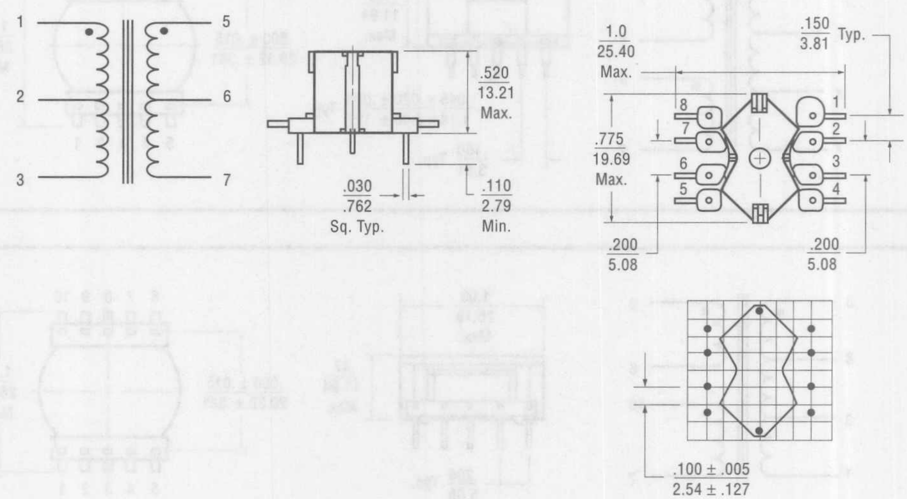


Figure 5



OUTLINE DIMENSIONS (Inch/mm)

Figure 6

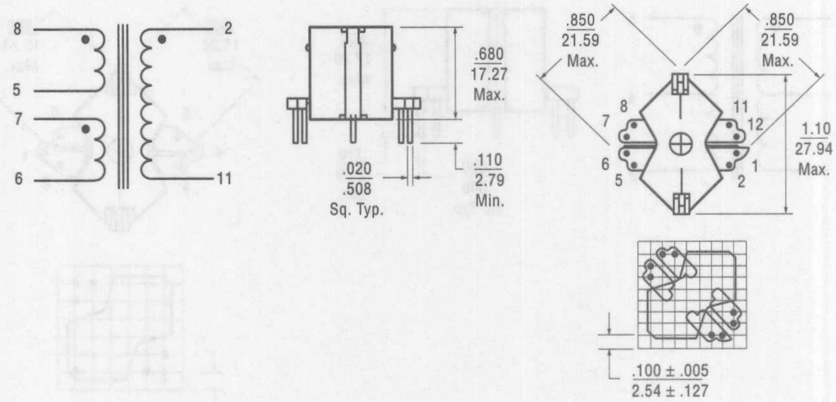


Figure 7

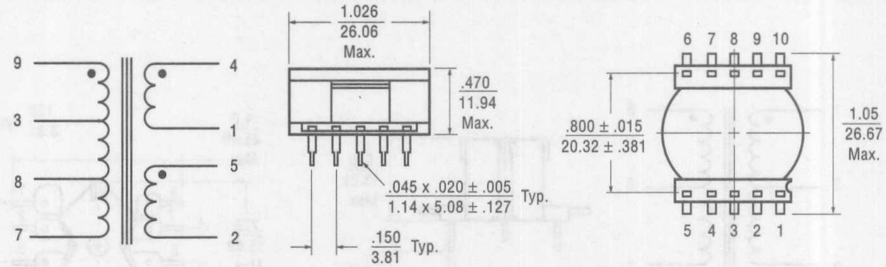
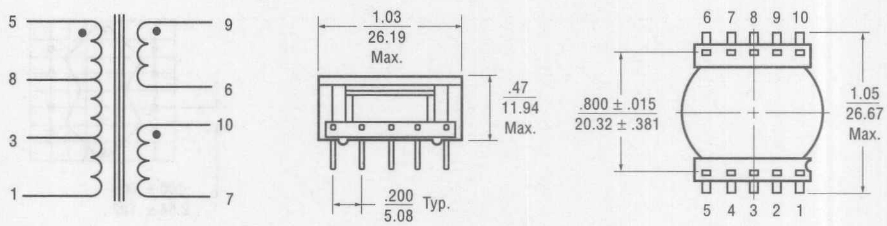


Figure 8



OUTLINE DIMENSIONS (Inch/mm)

Figure 9

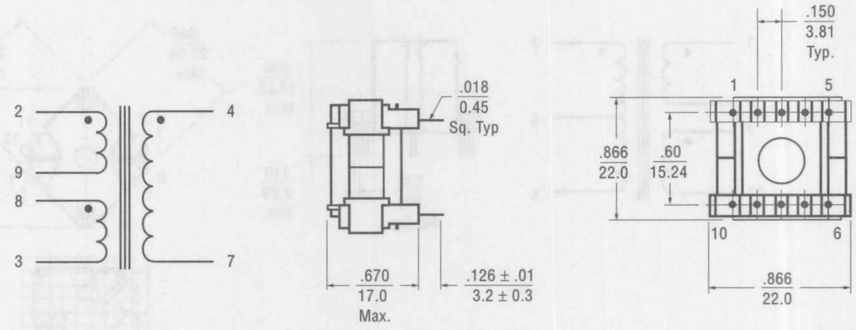


Figure 10

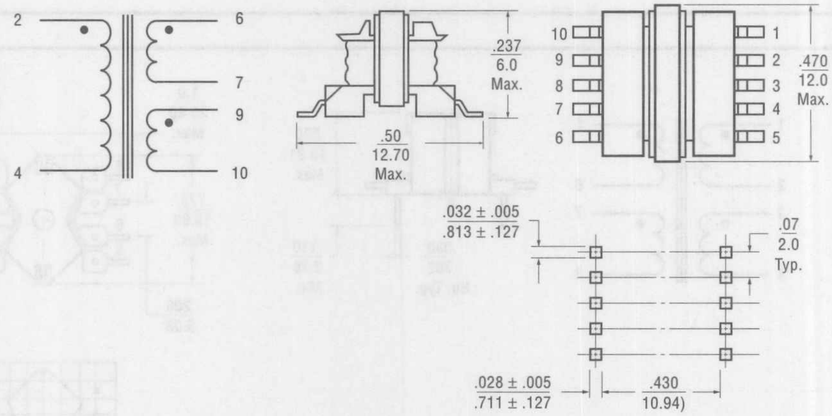


Figure 11

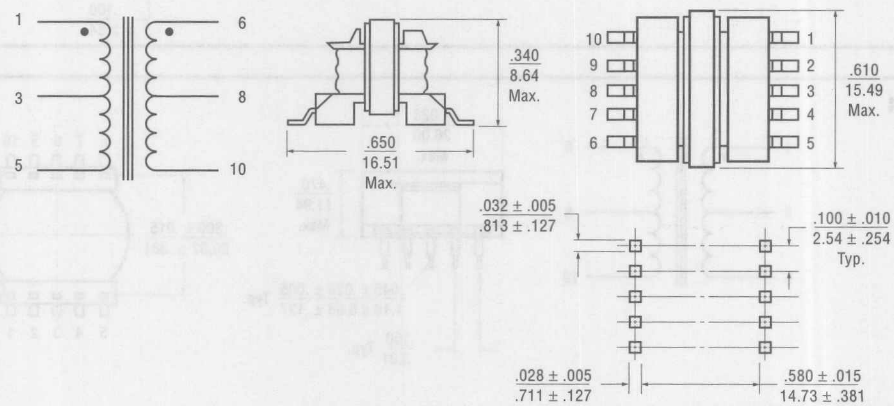


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Figure 12

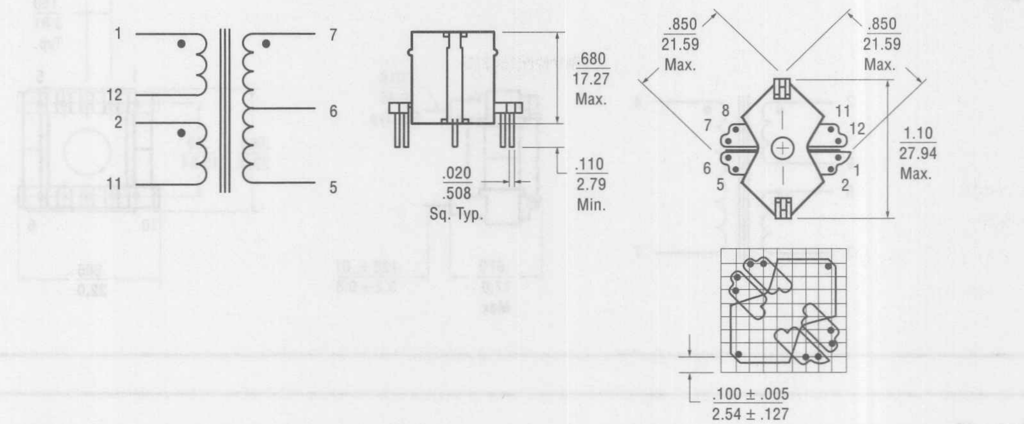


Figure 13

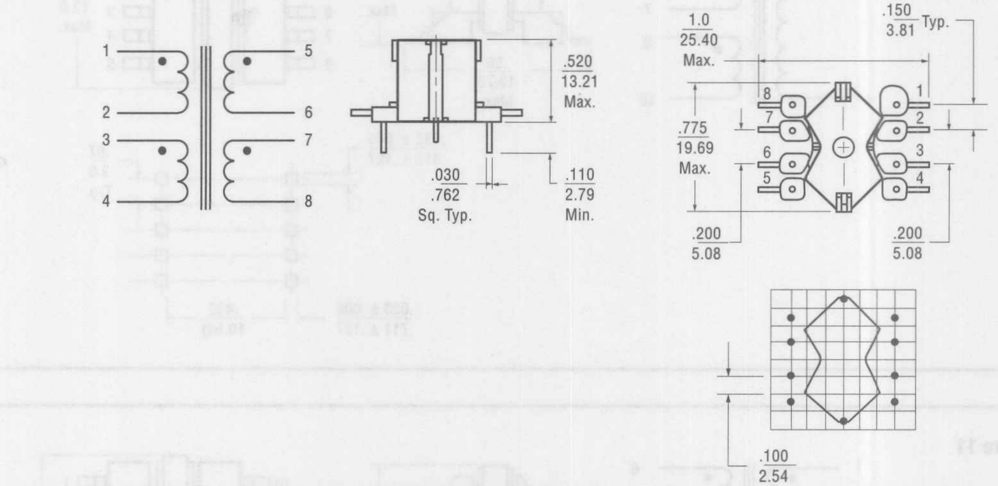
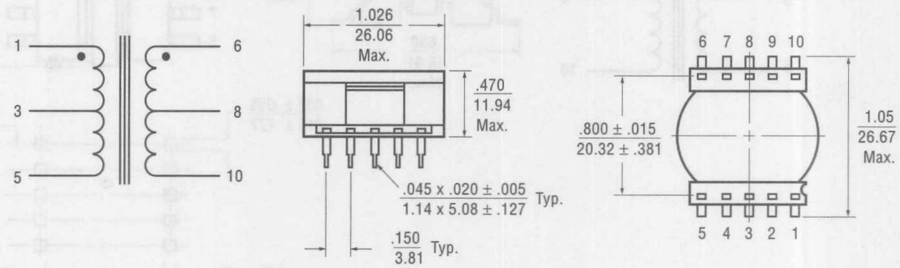


Figure 14



CUSTOM MAGNETIC CAPABILITIES

BI Technologies manufactures a wide array of magnetic components for power applications. Our magnetic components are manufactured in accordance with the current revisions of IEC 950, VDE 0806, UL 1950, and applicable customer specification. The primary manufacturing facilities are located in Pekan, Malaysia. They occupy a total floor space of 59,000 sq. ft. and currently employ about 2,000 people in the manufacturing of custom magnetic components. Our manufacturing facilities are surveyed and approved by international safety agencies, such as UL, VDE, and TUV. They are also certified as ISO-9002 factories.

Manufacturing is supported by comprehensive design capability and full engineering back-up in Fullerton, California. High manufacturing efficiency, statistical process control and sophisticated production equipment enable us to support most OEM customer requirements.

Our magnetic products are ferrite based transformers and inductors. These differ significantly from the more common steel laminated transformers and inductors. The steel laminated transformer operates at 50/60 Hz frequency. It is old technology and is being replaced in many applications by high frequency switching mode designs. The ferrite based magnetics allow the magnetic components to be much smaller for the same output. Our magnetics can provide a wide frequency range from 20 Khz to 1 Mhz and power level from Milli-Watts to about 1000 Watts.

We specialize in power products. We can supply a wide variety of switching mode magnetic components including ETD core, EE core, RM core, POT core, Toroid core, and in through hole and low profile SMD packages. Audio transformers which utilize homogeneous ferrite core are considered to be in our products category. Our winding capabilities range from 14 AWG to 45 AWG.

Please refer to product capability matrix in this section for a more complete capability profile.

We work closely with many world class ferrite and bobbin suppliers to meet uncommon, as well as common, customer requirements.

To initiate a request, either contact your local BI representative or complete the custom magnetics request form and fax to BI magnetics marketing at (714) 447-2701.

Application Notes
Magnetics

6

DETERMINING L_{MIN} FOR BUCK AND BOOST TYPE CONVERTERS

FUNDAMENTAL CONCEPTS

DEFINITION OF INDUCTANCE: When current flows through a coil, a magnetic field is established around the coil. The magnetic field can be expressed in terms of flux lines and is symbolized by the Greek letter ϕ with the unit of measurement in Webers (one Weber equals 10^8 flux lines). A flux linkage is one flux line encircling the circuit current once. Thus, a coil consisting of N turns would (neglecting leakage flux effects) have $N\phi$ flux linkages for each ampere of current through the coil. Inductance is, by definition, the number of flux linkages per ampere of current. Putting this in the form of an equation gives:

$$L = N\phi/i \qquad (1)$$

Where **L** is the inductance in henrys, **N** is the number of turns, ϕ is the number of magnetic flux lines in webers, and **i** is the current in amperes.

INDUCTOR VOLTAGE: Faraday's law states that the induced voltage, e, across an inductor is equal to the time rate of change of magnetic flux linkages, or:

$$e = d(N\phi)/dt = N d\phi/dt \qquad (2)$$

Combining equations 1 and 2 gives

$$e = L di/dt \qquad \text{(Lenz's Law)} \qquad (3)$$

where **e** is in volts, and **t** is in seconds. This equation makes the assumption that the magnetic properties of the surrounding medium (primarily the magnetic core) are not functions of the current or physical environment, and that the properties of the inductor do not change with time. Actually, L does vary with magnetizing force, which in turn is a function of the current through the coil. However, for the purposes of calculating L_{MIN}, the effect is not significant if operation is constrained to the nearly linear portion of the B-H curve as explained in the next few sections.

B-H (HYSTERESIS EFFECTS): Fig. 1 shows the familiar B-H hysteresis loop of a typical ferromagnetic core material. When a magnetizing force, H, (proportional to NI) is first applied, the flux density, B, changes in a fairly linear fashion along the path o-a. Further increase of H, however, fails to increase B at the same rate because the material saturates, i.e., the material becomes fully magnetized. This is indicated in Fig. 1 as B_{SAT}.

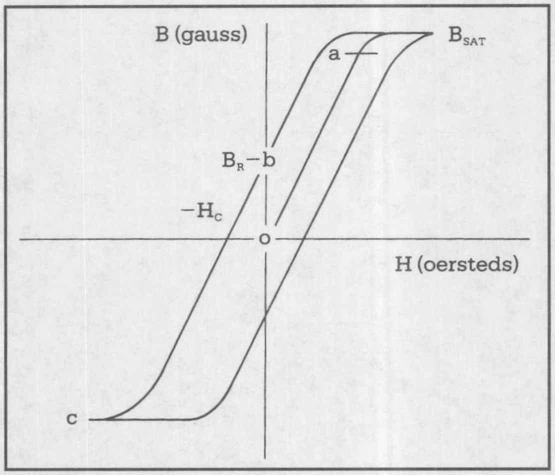


FIGURE 1. B-H Loop

The ratio of B to H is the permeability, μ, of the core material; and the slope of line o-a is referred to as the initial permeability. When the magnetizing force is returned to zero, the flux density does not retrace along a-o, but instead, follows a different path to point b, which is called the residual flux density, B_R. This occurs because the core material inherently has memory which retains magnetic information. At this point a negative value of H, called the coercive force, H_C, must be applied to return B to zero. If the magnetizing force is increased further in the negative direction, the flux density will move to point c.

Continued reversal of the magnetizing force produces the hysteresis loop shown in Fig. 1, where the area under the loop is directly proportional to the energy required to magnetize the core.

INCREMENTAL INDUCTANCE: If an inductor is driven in one direction by DC, upon which is superimposed a small AC signal, the relationship between B and H is described by the minor hysteresis loop shown in Fig. 2. Under these conditions, it is the inductance that is offered to the superimposed AC signal that is of interest. This is called the incremental inductance, and the corresponding permeability, which is the slope of the B-H curve at the instantaneous point of operation, is the incremental permeability, $\Delta B/\Delta H$. As seen in both Fig. 1 and Fig. 2, the incremental permeability falls off rapidly as the flux density approaches B_{SAT}.

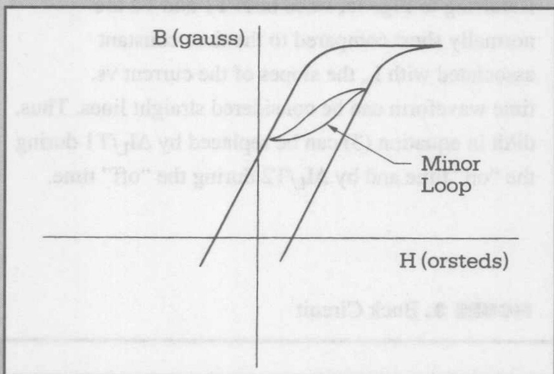


FIGURE 2. B-H Minor Loop

Elementary magnetic circuit analysis provides a relationship between the inductance, the magnetic properties of the core, and the physical configuration of the flux path as follows:

$$L = 0.4\pi N^2 K \bullet 10^{-8} \text{ Henrys} \qquad (4)$$

where N is the number of turns, and K is a factor that is directly proportional to the permeability of the magnetic material, directly proportional to the cross sectional area of the magnetic path and inversely proportional to the length of the path (including air-gap if present).

Since the incremental permeability changes as a function of operating point, it follows from equation (4) that the inductance also changes. In forward type converters, however, the minimum inductance is selected (by design) to be of such value as to ensure that the AC component of current through the inductor, referred to as the inductor ripple current, is normally only 10% to 20% of the average inductor current. This results in a relatively small minor B-H loop with a fairly constant slope, thus, the value of inductance can be considered constant over the complete AC current variation, as long as the average flux density is maintained sufficiently below B_{SAT}.

ENERGY STORAGE IN AN INDUCTOR: An alternative definition of inductance states that it is a measure of the ability of an inductor to store energy in a magnetic field. It is important to emphasize that an inductive device stores energy as opposed to dissipating energy. It is this property of inductors that makes them ideal for use in feed-forward type converters. The total energy input, W_L, in joules is directly proportional to the square of the final current in amperes, and the factor of proportionality is L/2, where L is in henrys. Expressed as an equation:

$$W_L = 1/2\ L I_L^2 \text{ Joules} \qquad (5)$$

Actually, there are energy losses which prevent 100% of the input energy from being stored and ultimately transferred to an output. The energy required to magnetize the core (referred to as hysteresis loss) and eddy current loss in the core, itself, make up the so-called core losses. Also contributing are the copper losses, i.e., energy dissipated in the coil as a result of the coils DC resistance and the frequency dependent skin-effect resistance.

CONTINUOUS VS. DISCONTINUOUS CONVERTER OPERATION: A forward type converter is said to be operating in "continuous mode" as long as the current through the inductor remains above zero for the entire switching cycle. If, at minimum output current, the current through the inductor drops to and remains at zero during some portion of the inductor discharge cycle, the converter is being operated in "discontinuous mode." Forward converters can be operated in either continuous or discontinuous mode; and by definition, L_{MIN} is that value of inductance, below which, the converter just becomes discontinuous at minimum output current.

CALCULATING MINIMUM INDUCTANCE FOR A BUCK TYPE CONVERTER

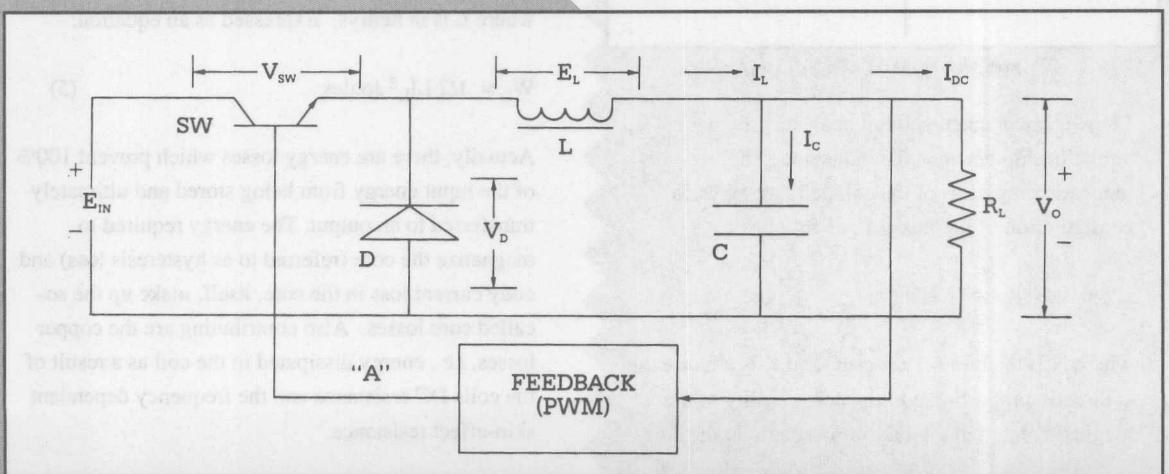
INDUCTOR RIPPLE CURRENT: Referring to Fig.'s 3 and 4, during T1 (SW_{ON}), the current through the inductor increases, and additional energy is stored in the inductor's magnetic field in accordance with equation (5). During T2 (SW_{OFF}), the current decreases, and the added energy (minus the losses) is transferred to the load. The output voltage, V_O, is maintained at a steady preset value by virtue of the pulse width modulation (PWM) feedback loop. The variation in current through the inductor is the ripple current. Since the load current, I_{DC}, is constant (for a given V_O and load resistance, R), it is apparent that the capacitor, C, is "absorbing" the variations in I_L, acting as a current sink for the inductor during the time interval, x-y, and a current source for the load during y-z. The larger the value of C, the lower will be the output ripple voltage.

SWITCH ON AND OFF TIMES: In order to determine a minimum required inductance value, it is necessary to calculate the period of time during which energy is either added to or transferred from the inductor. In addition the following circuit parameters must be known:

a) Power supply switching frequency, F
b) DC supply voltage, E_{IN}
c) Output voltage, V_O
d) Output current, I_{DC}

Referring to Fig. 4c, since both T1 and T2 are normally short compared to the time constant associated with L, the slopes of the current vs. time waveform can be considered straight lines. Thus, di/dt in equation (3) can be replaced by $\Delta I_L/T1$ during the "on" time and by $\Delta I_L/T2$ during the "off" time.

FIGURE 3. Buck Circuit



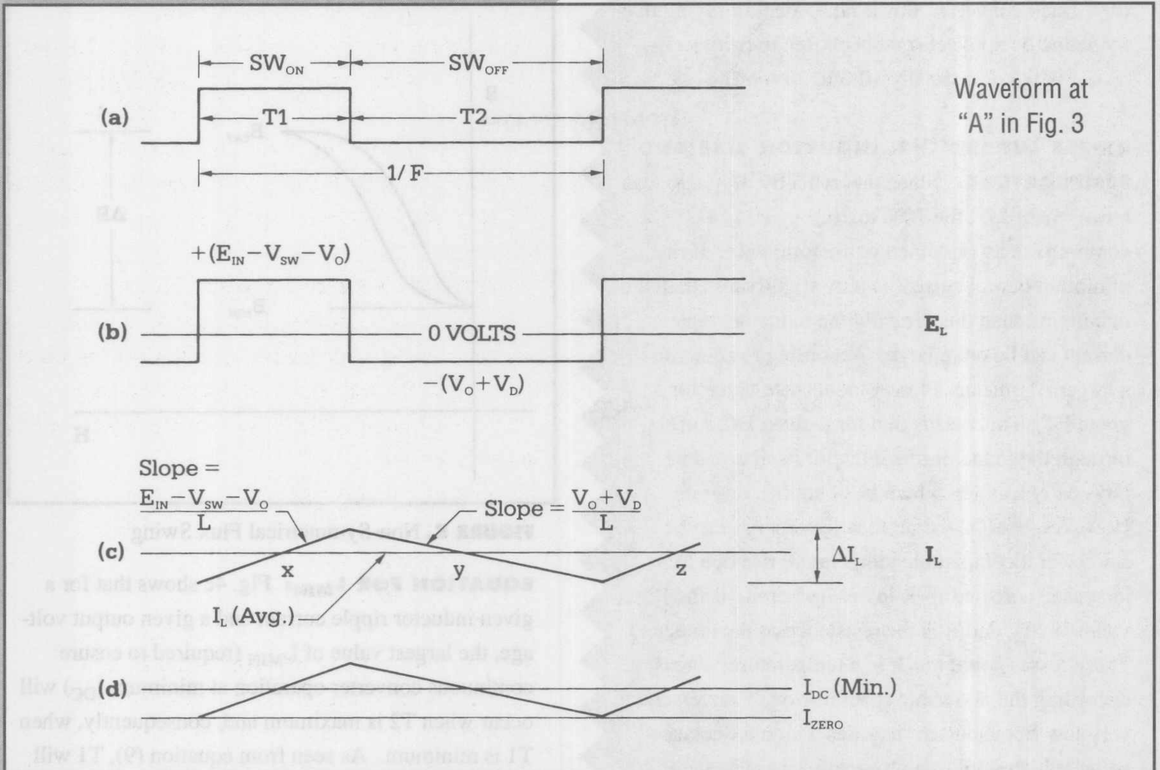


FIGURE 4. Buck Circuit Waveforms

During T1, equation (3) becomes:

$E_{L\,1} = E_{IN} - V_O - V_{SW} = L\Delta I_L / T1$ (6)

and during T2:

$E_{L\,2} = V_O + V_D = L\Delta I_L / T2$ (7)

Thus:

$(E_{IN} - V_O - V_{SW})\ T1 = (V_O + V_D)\ T2$ (8)

Equations (6) and (7) show that since ΔI_L is the same for both T1 and T2, inductance can be calculated simply by knowing ΔI_L plus the voltage across the inductor during the corresponding period. In this case the expression for T1 will be used. Solving equation (8) for T2 and adding T1 to both sides gives:

$T1 = (V_O + 0.5) / FE_{IN}$ (9)

where V_{SW} and V_D are assumed to be 0.5V and $F = 1 / (T1 + T2)$

DETERMINING INDUCTOR RIPPLE CURRENT: Since F is constant, equation (9) shows that T1 (and consequently T2) is dependent only on the DC input and output voltages. Thus, for a given V_O, as long as E_{IN} remains unchanged, the peak-to-peak ripple current, ΔI_L, will remain constant regardless of the value of $I_{L\ (AVG)}$, which, for a Buck type converter, equals the output current. As seen in Fig. 4d, as I_{DC} decreases, a point is reached where the current through the inductor just reaches zero. A further decrease in IDC results in "discontinuous operation" of the converter. Although it is possible to operate in discontinuous mode, such operation places more stringent criteria on the design of the power supply. For this reason ΔI_L is normally chosen to be no more than twice the minimum value of the current through the inductor - which in turn is normally chosen to be 10% to 20% of the maximum inductor current; and

for a Buck converter, this is equivalent to saying that the inductor ripple current is chosen to be twice $I_{DC\ (MIN)}$, which is normally 10% to 20% of $I_{DC\ (MAX)}$.

RIPPLE CURRENT VS. INDUCTOR SIZE AND TEMPERATURE: Since theoretically, $I_{DC\ (MIN)}$ can be any % of I_{DC}, the 10% to 20% figure is a compromise as explained in the following: If the minimum output current is only slightly less than the maximum, then theoretically the inductor ripple current can be quite large. According to equation (3), a larger ΔI_L means a lower inductance value for a given ET. This means that for a given DC current through the inductor, the inductor itself could be physically smaller, which is, of course, desirable. However, if ΔI_L is large, then less energy can be stored for a comparable temperature rise due to increased core and $I_L{}^2R$ losses, (where I_L is the RMS value of ΔI_L, and R is the resistance of the inductor). These losses could result in a temperature increase exceeding the allowable specification. Conversely, a very low ripple current requires a high inductance value, which implies a physically larger inductor. Therefore, a compromise must be made in the ripple current that maintains both the inductor size and temperature rise at acceptable levels.

CORE SATURATION: A further complication of a large AC ripple current is the fact that it produces a larger flux swing on the B-H loop of the inductor core. Fig. 5 shows that if the average current through the inductor is generating a core flux close to the knee of the B-H curve, then a large ripple current could cause the core to saturate during the positive peaks.

It is important to note that unlike the current through the inductor, which can have both a DC and an AC component, Faraday's Law states that the average voltage across an inductor over a complete cycle must be zero (see Fig. 4b).

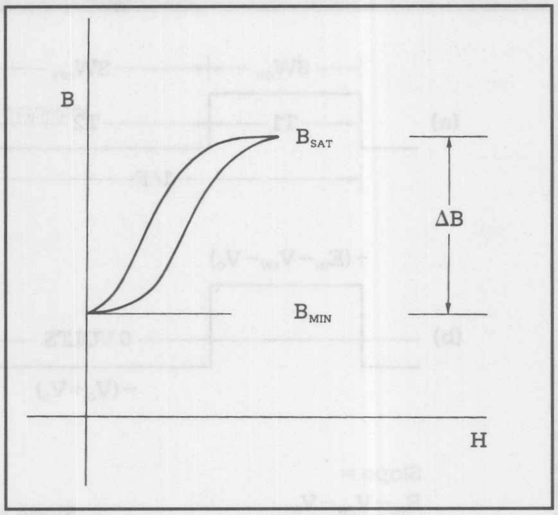


FIGURE 5. Non-Symmetrical Flux Swing

EQUATION FOR L_{MIN}: Fig. 4c shows that for a given inductor ripple current and a given output voltage, the largest value of L_{MIN} (required to ensure continuous converter operation at minimum I_{DC}) will occur when T2 is maximum and, consequently, when T1 is minimum. As seen from equation (9), T1 will be minimum when E_{IN} is maximum. Once T1 and ΔI_L are known, an expression for the minimum inductance can be derived using equation (6):

$$L_{MIN} = (E_{IN\ (MAX)} - V_O - 0.5)\ T1_{MIN} / \Delta I_L \qquad (10)$$

VOLT-SECONDS DEFINED: The numerator of equation (10) is the volt-seconds of the inductor, commonly referred to simply as the "ET." Most manufacturers of switching type magnetic components provide a maximum ET as well as a nominal inductance value for inductors designed for energy storage applications. Knowing these parameters, equation (10) can be used for a Buck converter to determine the peak AC current that the inductor can safely handle without core saturation.

Equation (8) and Fig. 4b show that the ET's during both T1 and T2 are equal. If this were not the case, the core would not "reset" during each cycle, i.e., the

amount of energy added during T1 would not equal the energy transferred during T2, and the core would quickly saturate.

BUCK CONVERTER DESIGN EXAMPLE: The following is a design of the minimum required inductance for a Buck type converter with the following specifications:

Input Voltage	+22V to +26V
Output Voltage	+5V
Switching Frequency	50KH$_Z$
Max DC Output Current	2.5 Amps
Min DC Output Current	0.5 Amps

Using the maximum input voltage, equation (9) gives the minimum on-time of the transistor switch as follows:

$T1_{MIN} = (5+0.5) / 26 \bullet 50000 = 4.23$ µseconds

Selecting a value of 1 amp for the inductor ripple current (twice the minimum value of DC output current), and substituting in equation (10) gives for L_{MIN}:

$L_{MIN} = (26-5-0.5)(4.23 \bullet 10^{-6}) / 1 = 86.7$ µhenrys

CALCULATING MINIMUM INDUCTANCE FOR A BOOST TYPE CONVERTER

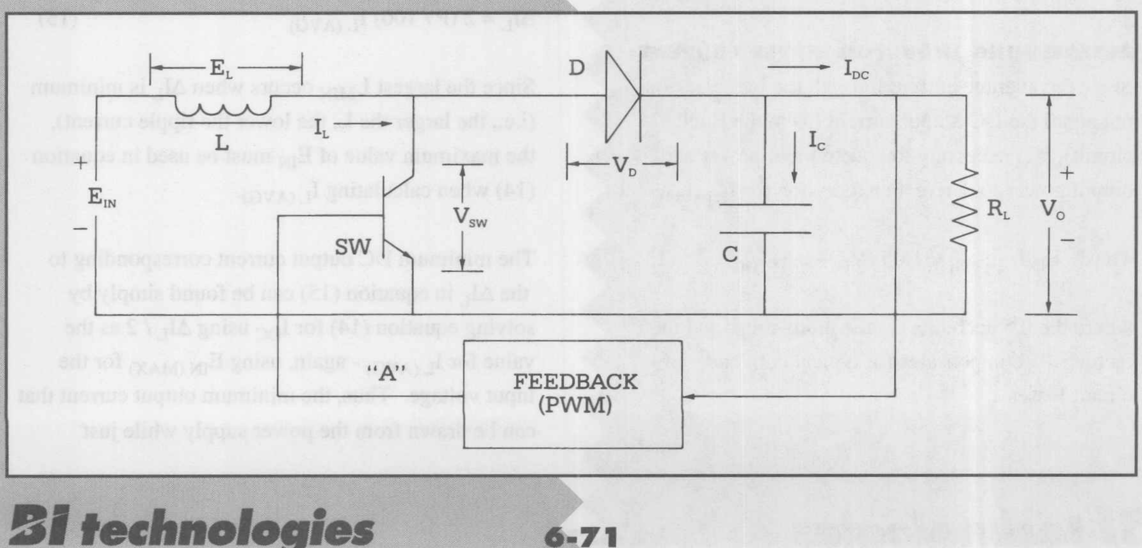
CIRCUIT ANALYSIS: The analysis for the Boost converter is similar to that for the Buck with one basic difference. As seen in Fig. 6, the current through the inductor does not flow continuously to the output as in the Buck converter. Instead, during T1 (SW_{ON}), the output end of the inductor is switched (essentially) to ground, and diode, D, is reversed biased. Thus, during T1, the entire output current must be supplied by the output capacitor, C. During T2 (SW_{OFF}), the output end of the inductor swings positive, the diode becomes forward biased, and a positive output voltage is produced. The actual value of V_O is determined by the relative on/off times of SW. As seen in Fig. 7b, V_O must exceed E_{IN} in order for the average voltage across L to equal zero as required.

SWITCH ON AND OFF TIMES: Since the average voltage across the inductor must be zero, Fig. 7b gives:

$$(E_{IN} - V_{SW})\ T1 = (V_O + V_D - E_{IN})\ T2 \qquad (11)$$

6

FIGURE 6. Boost Circuit



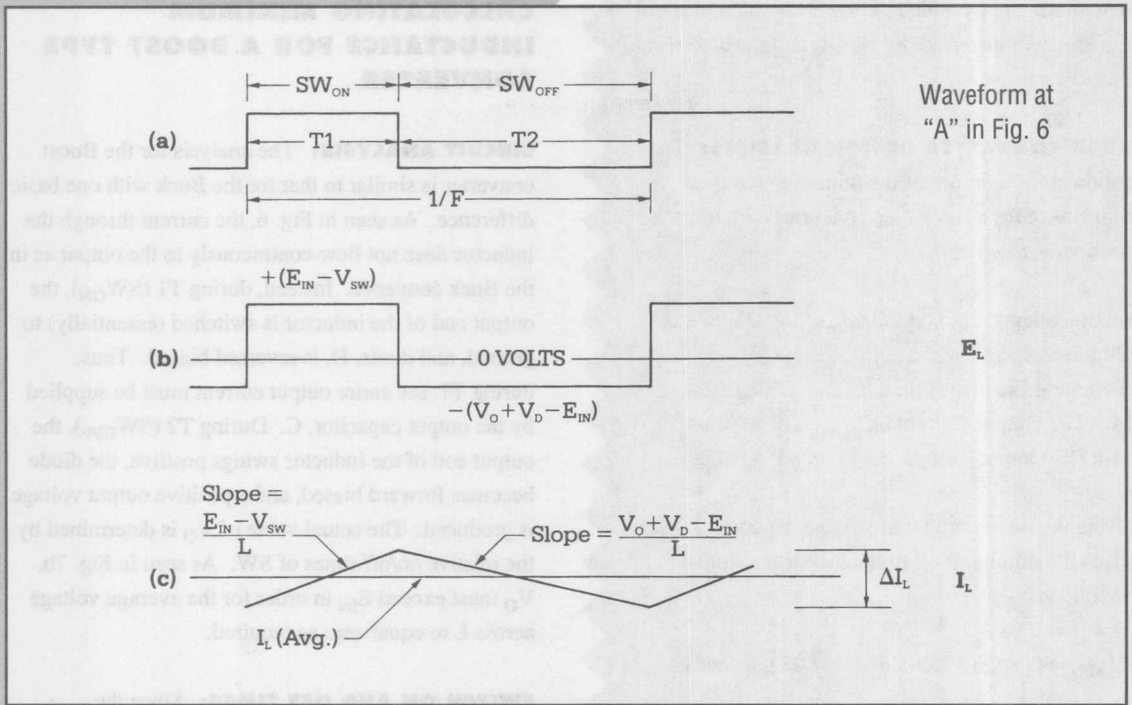


FIGURE 7. Boost Circuit Waveforms

Solving equation (11) for T2 and adding T1 to both sides gives:

$$T1 = (V_O - E_{IN} + 0.5) / FV_O \qquad (12)$$

where V_{SW} and V_D are again assumed to be 0.5V

DETERMINING INDUCTOR RIPPLE CURRENT: Since the average current through the inductor does not equal the DC output current (as in the Buck circuit), it is necessary to equate input power and output power to derive an expression for $I_{L\,(AVG)}$.

Thus: $$E_{IN}I_{L\,(AVG)} = 1.05\,(V_O + 0.5)\,I_{DC} \qquad (13)$$

where the 0.5 accounts for the diode drop, and the factor 1.05 compensates for typical core and circuit losses.

And: $$I_{L\,(AVG)} = 1.05\,(V_0 + 0.5)\,I_{DC} / E_{IN} \qquad (14)$$

Assuming a ΔI_L at twice the minimum I_L, and a minimum I_L at P% of $I_{L\,(AVG)}$, gives for the inductor peak-to-peak ripple current, ΔI_L:

$$\Delta I_L = 2\,(P / 100)\,I_{L\,(AVG)} \qquad (15)$$

Since the largest L_{MIN} occurs when ΔI_L is minimum (i.e., the larger the L, the lower the ripple current), the maximum value of E_{IN} must be used in equation (14) when calculating $I_{L\,(AVG)}$.

The minimum DC output current corresponding to the ΔI_L in equation (15) can be found simply by solving equation (14) for I_{DC} using $\Delta I_L / 2$ as the value for $I_{L\,(AVG)}$ - again, using $E_{IN\,(MAX)}$ for the input voltage. Thus, the minimum output current that can be drawn from the power supply while just

maintaining continuous operation is:

$I_{DC\,(MIN)} = \Delta I_L E_{IN\,(MAX)} / [2.1\,(V_O + 0.5)]$ (16)

Conversely, equation (16) can be used to solve for a ΔI_L corresponding to a specified $I_{DC\,(MIN)}$.

Thus: $\Delta I_L = 2.1\,(V_O + 0.5)\,I_{DC\,(MIN)} / E_{IN\,(MAX)}$ (17)

EQUATION FOR L_{MIN}: The voltage across the inductor during T1 was seen to be:

$E_{L1} = E_{IN} - V_{SW}$ (18)

which, from equation (3) becomes:

$E_{L1} = E_{IN} - V_{SW} = L\Delta I_L / T1$ (19)

As was the case for the Buck converter, the largest value of L_{MIN} will occur when T2 is maximum and T1 is minimum; and as before, T1 is minimum when E_{IN} is maximum, thus:

$L_{MIN} = (E_{IN\,(MAX)} - 0.5)\,T1_{MIN} / \Delta I_L$ (20)

BOOST CONVERTER DESIGN SAMPLES: The following are calculations of the minimum inductance for two Boost type converters:

Example Number 1:

Input Voltage ....+ 12V to + 15V
Output Voltage ....+ 24V
Switching Frequency ....50 KH_Z
Max DC Output Current................1.5 Amps
Min DC Output Current ....Not Specified

Assume a maximum inductor ripple current of 12.5% of $I_{L\,(AVG)}$

From (12): $T1_{MIN} = (24 - 15 + 0.5) / 50000 \bullet 24$
$= 7.92$ µseconds

From (14): $I_{L\,(AVG)} = 1.05\,(24 + 0.5)\,1.5 / 15$
$= 2.57$ Amps

From (15): $\Delta I_L = 2 \bullet 0.125 \bullet 2.57 = 0.643$ Amps

From (20): $L_{MIN} = (15 - 0.5)\,(7.92\,1\,10^{-6}) / 0.643$
$= 179$ µhenrys

The minimum DC output current corresponding to a ΔI_L of 0.643 Amps is:

From (16): $I_{DC\,(MIN)} = 0.643 \bullet 15 / [2.1\,(24 + 0.5)]$
$= 0.19$ Amps

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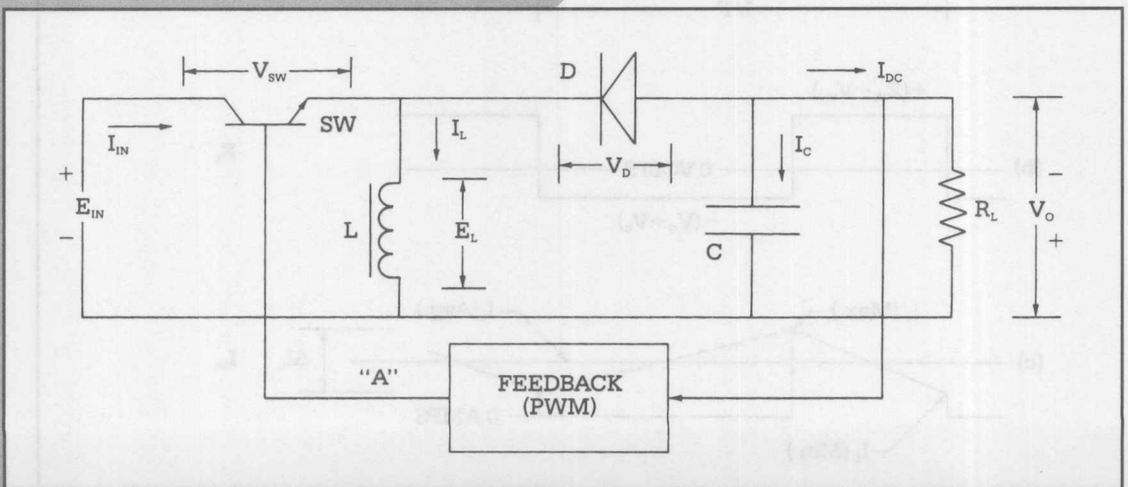
FIGURE 8. Buck-Boost Circuit



Example Number 2 - Same as example 1 except $I_{DC\,(MIN)}$ is specified at 0.1 Amps:

From (17): $\Delta I_L = (2.1 \bullet 0.1)\,(24 + 0.5) / 15$
$= 0.343$ Amps

From (20): $L_{MIN} = (15 - 0.5)\,(7.92 \bullet 10^{-6}) / 0.343$
$= 335$ μhenrys

CALCULATING MINIMUM INDUCTANCE FOR A BUCK-BOOST CONVERTER

CIRCUIT ANALYSIS: The analysis for the Buck-Boost converter, shown in Fig. 8, is similar to that of the Boost in that $I_{L\,(AVG)}$ is determined by equating input and output power. However, the Buck-Boost is somewhat more complex because of the on/off characteristic of the input current, I_{IN}, as shown in Fig. 9c. During T1 (SW_{ON}), the input current charges the inductor, i.e., the inductor current changes from $I_{L\,(MIN)}$ to $I_{L\,(MAX)}$. During T2 (SW_{OFF}), the input current drops to zero and the inductor current decreases back to $I_{L\,(MIN)}$. Since the average input current during T1 is simply $I_{L\,(AVG)}$, and during T2 is zero, the average input current over a complete period is:

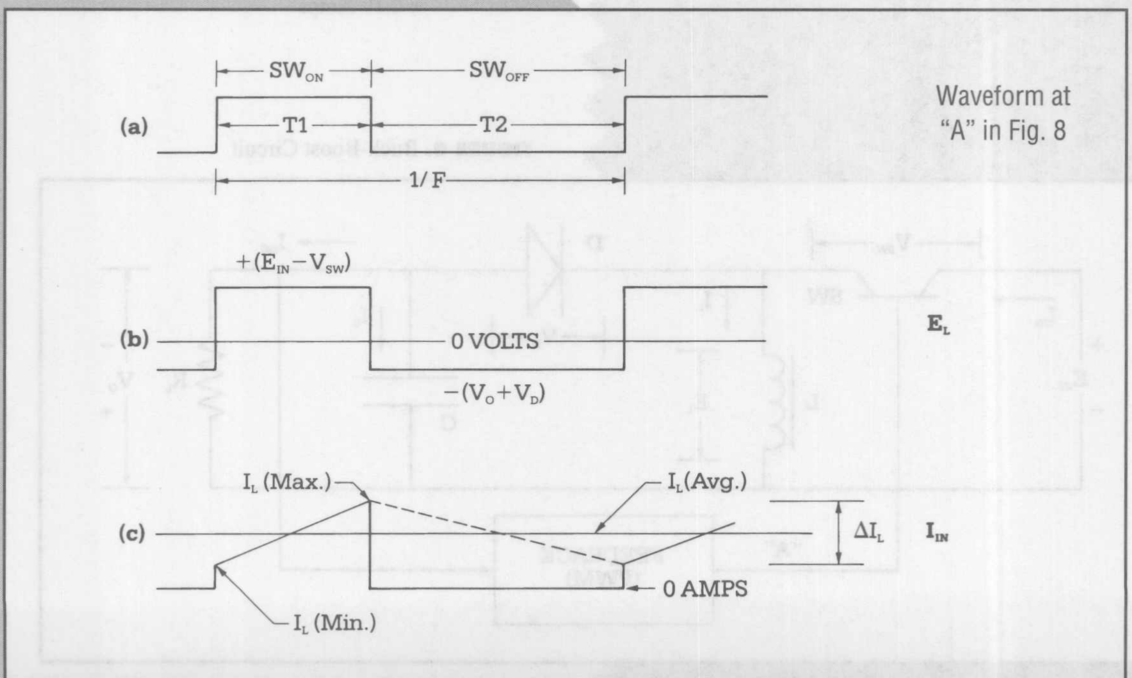
$$I_{IN\,(AVG)} = I_{L\,(AVG)} \bullet T1/(T1+T2) = F \bullet T1 \bullet I_{L\,(AVG)} \qquad (21)$$

From Fig. 9b and equation (21) it is now possible to write an expression for Power-In equal to Power-Out which involves $I_{L\,(AVG)}$:

$$E_{IN} \bullet F \bullet T1 \bullet I_{L\,(AVG)} = 1.05\,(V_O + 0.5)\,I_{DC} \qquad (22)$$

where, again, the 0.5 accounts for the diode drop and the 1.05 compensates for typical core and circuit losses.

FIGURE 9. Buck-Boost Circuit Waveforms



Solving equation (22) for $I_{L\,(AVG)}$ gives:

$$I_{L\,(AVG)} = 1.05\,(V_O + 0.5)\,I_{DC} / [E_{IN} \bullet F \bullet T1] \quad (23)$$

Referring again to Fig. 9b, it is obvious that V_O must be of opposite polarity to E_{IN} in order to satisfy the requirement that the average voltage across L be zero. Thus, the Buck-Boost circuit not only can step a voltage up or down (as its name implies), but it also provides polarity reversal.

SWITCH ON AND OFF TIMES: From Fig. 9b:

$$T1\,(E_{IN} - V_{SW}) = T2\,(V_O + V_D) \quad (24)$$

Solving equation (24) for T2 and adding T1 to both sides gives:

$$TI = (V_O + 0.5) / [F\,(E_{IN} + V_O)] \quad (25)$$

DETERMINING INDUCTOR RIPPLE CURRENT: The expression for the inductor ripple current for the Buck-Boost converter is the same as that for the Boost, namely:

$$\Delta I_L = 2\,(P / 100)\,I_{L\,(AVG)} \quad (26)$$

The $I_{DC\,(MIN)}$ corresponding to ΔI_L in equation (26) is found (as before) by solving equation (23) for I_{DC} using $\Delta I_L / 2$ in place of $I_{L\,(AVG)}$.

$$I_{DC\,(MIN)} = \Delta I_L\,E_{IN\,(MAX)} / [2.1\,(E_{IN\,(MAX)} + V_O)] \quad (27)$$

And, conversely, if $I_{DC\,(MIN)}$ is specified, equation (27) can be used to calculate the corresponding ΔI_L.

$$\Delta I_L = 2.1\,(E_{IN\,(MAX)} + V_O)\,I_{DC\,(MIN)} / E_{IN\,(MAX)} \quad (28)$$

EQUATION FOR L_{MIN}: As seen from equation (25), T1 is minimum and T2 is maximum (which corresponds to the largest L_{MIN}) when E_{IN} is maximum, thus:

$$L_{MIN} = (E_{IN\,(MAX)} - 0.5)\,T1_{MIN} / \Delta I_L \quad (29)$$

Buck-Boost Converter Design Example: The following is a design of the minimum required inductance for a Buck-Boost converter with the following specifications:

Input Voltage ....+15V to +20V
Output Voltage ....-12V
Switching Frequency......................40KH$_Z$
Max DC Output Current..................0.75 Amp
Assume a minimum ripple current of 12.5% of $I_{L\,(AVG)}$

From (25): $T1 = 12.5 / 40000\,(20 + 12) = 9.77$ µseconds

From (23): $I_{L(AVG)} = 1.05 \bullet 12.5 \bullet 0.75 / (20 \bullet 40000 \bullet 9.77 \bullet 10^{-6}) = 1.26$ Amps

From (26): $\Delta I_L = 2 \bullet 0.125 \bullet 1.26 = 0.315$ Amps

Thus, from (29): $L_{MIN} = (20 - 0.5)\,(9.77 \bullet 10^{-6}) / 0.315 = 605$ µhenrys.

Hybrid Microcircuits

7

	DESCRIPTION	TYPICAL ASSEMBLY
Military Hybrids: 165-XXXX	Custom Microcircuit	Epoxy mounted chip and wire
Commercial Hybrids: 143-XXXX	Custom Sub-Assembly	Surface mount components
Power Modules: 170-XXXX	Custom Power Module	Solder mount die/ Aluminum wire bond
7700	High Power PFC	Solder mount die/ Aluminum wire bond
7710-X	Medium Power PFC	Solder mount die/ Aluminum wire bond

	TYPICAL PACKAGE TYPE	OPERATING TEMPERATURE RANGE
Military Hybrids: 165-XXXX	Hermetic: KOVAR® or Ceramic	-55° to 125°C
Commercial Hybrids: 143-XXXX	Conformal coated or uncoated	0° to 70°C
Power Modules: 170-XXXX	Encapsulated	-40° to 125°C
7700	Encapsulated	-40° to 125°C
7710-X	Encapsulated	-40° to 125°C

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ADDITIONAL DESIGNS*

DC Voltage Regulators

801 Fixed output +9V to +21V
802 Adjustable output +9V to +21V
804 Adjustable output +20V to +32V
805 Fixed output +3V to +9V
806 Adjustable output +3V to +9V
809 Fixed output +5V to +28V
851 Fixed output -9V to -21V
852 Adjustable output -9V to -21V
856 Adjustable output -3V to -9V
859 Fixed output -5V to -28V

Power Amplifiers

822 Unity gain power amp 40Mhz
823 Unity gain power amp 4Mhz

* The products featured on this page are not recommended for new designs. Consult factory for other products in this series.

Active Component:	An electronic component such as an IC, transistor, or diode.
Active Trim:	The trimming of a circuit element (resistor) to obtain a specific functional output.
Alumina:	Aluminum Oxide. The primary compound in Alumina (ceramic) substrates.
Analog Circuit:	A circuit, comprised of linear components, that provides a linear function.
Bond:	An electrical interconnection, i.e., wire bond.
Burn-in:	Subjecting a part to electrical bias or load at elevated temperature for a specific period of time in order to promote failure of marginal devices.
Ceramic Package:	Hybrid package enclosure consisting of an inorganic, nonmetallic material such as alumina.
Cermetic Package:	A package constructed with a substrate base, a glass attached frame, and a metalized ring for lid attachment; a low cost method for achieving hermeticity.
Chip:	The uncased and normally leadless form of an electronic component.
Chip-and-wire:	A hybrid assembly technology employing face-up wire bonded chip devices.
Clean room:	A manufacturing area where the air is filtered to remove dust particles.
Cofired Ceramic Package:	Process of firing conductor and ceramic package elements at the same time to yield a package with no glass feedthroughs for leads.
Conformal Coating:	A thin nonconductive coating, such as plastic, applied to a circuit for protection.
Constant Acceleration (Centrifuge):	The testing of the integrity of the attachment of components of a hybrid by spinning the unit at high speed to impart high g force on to the components.
Die:	Uncased component obtained from a semiconductor wafer (see chip).
Digital Circuit:	A circuit design consisting primarily of digital ICs.
Encapsulate:	Sealing or covering an element or circuit for environmental protection.
Eutectic Die Attach:	A method of die attach where an intermetallic bond is formed between the back of the die and the circuit pad metalization to achieve an electrical interconnect, without the use of solder or epoxy.
Failure Analysis:	The analysis of a circuit to determine the reason for failure.
Film:	Layer or coating of thin or thick material used to form various elements, interconnections, or insulation.
Fire:	The act of heating a thick-film circuit so that the film will develop its final properties.
Flat Pack:	A microcircuit package having its leads extending from the sides and parallel to the base, often used to achieve surface mountability.
Flip Chip:	A method of mounting chips (ICs) without using wire bonds.
Glassivation:	A method of semiconductor passivation by coating the element with a pyrolytic glass deposition.
Header:	The base of a hybrid package that holds the leads.
Hermetic:	Sealed so as to be gas-tight.
Hybrid Microcircuit:	A microcircuit on an insulating substrate that consists of an assembly of various components and technologies including screened resistors, capacitors, and various integrated circuits.

Ink: Synonymous with "composition" and "paste" when relating to screenable thick-film materials.

Integrated Circuit: A multiple of transistors interconnected on a semiconductor.

Laser Trim: Adjustment of a film resistor (increasing value) using a laser to remove material.

Layer: One of several films in a multiple fire structure on a substrate.

Layout: A drawing depicting components and interconnection, used to generate artwork or masks for substrate metalization.

LCC: Leadless Chip Carrier, a package type.

Lead Frames: Metallic pins attached to the edge of a substrate to electrically interconnect the hybrid to the next level of assembly.

Leak Test: A package integrity check used to evaluate the hermeticity level; i.e. fine leak, gross leak.

Life Test: A test of a component under load over the rated life of the device, usually performed at elevated temperature.

Metalization: A film pattern of conductive material deposited on a substrate.

MCM: Multi-Chip Module. A hybrid microcircuit comprised of mostly digital circuitry.

Microcircuit: A small circuit (hybrid or monolithic) having a relatively high circuit density, which is considered as a single part with a single substrate to perform an electronic circuit function. (This excludes PC boards and modules composed exclusively of discrete electronic parts.)

Package: The container for an electronic component(s) with terminals to provide electrical access.

Passivation: An insulating layer directly over a circuit or element to protect the surface from contaminants such as moisture or loose particles.

Passive Component: Elements such as resistors, capacitors, and inductors.

Paste: See Ink.

PDA: Percent Defect Allowable. Maximum yield loss allowed before the complete lot of parts become suspect.

Plug-in Package: A microcircuit package with leads on one surface so that the part can be "plugged in" to a socket or through-hole board.

Potting: Encapsulation of a circuit using a polymeric material.

Power Dissipation: Power expended in the form of heat from within a device.

Power Factor: The ratio of actual power to perceived power in an AC signal.

Preform: Squares of epoxy or solder punched out of a sheet and used in manufacturing.

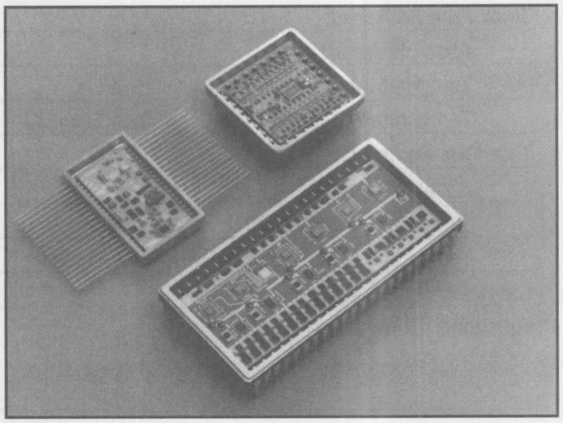
Reflow Soldering: Solder placement such as a screening operation that is subsequently followed by a reflow operation.

Schematic: Diagram of an electronic circuit showing all components and interconnect.

Screen:	The application of a circuit pattern onto a substrate using screen printing techniques.
Screen:	The subjection of a device to various environmental conditions and tests, to eliminate marginal devices.
Semiconductor:	The material used as substrates for devices such as transistors, diodes, and integrated circuits.
Snapstrate:	A scribed substrate that enables processing of multiple circuits that are latter separated (or snapped).
Standoff:	An insulative material affixed to the bottom of a package to give clearance or to prevent electrical shorting.
Substrate:	The supporting material upon which the elements of a hybrid are deposited or attached.
Temperature Cycling:	An environmental test where parts are subjected to a series of cycles alternating between low and high temperature extremes.
Temperature Tracking:	The degree to which similar elements on the same circuit exhibit change of a parameter with respect to temperature change.
Thermal Analysis:	A calculation to estimate the temperature rise of various elements in a microcircuit.
Thermal Shock:	Same as temperature cycling except that the rate of change of temperature is usually much more rapid.
Thick Film:	A film deposited by screen printing processes and fired at high temperature.
Thin Film:	A film deposited onto a substrate by deposition process such as sputtering or vacuum evaporation.
Trimming:	See Active Trim, Laser Trim.
Visual:	The process of visual inspection of a hybrid assembly for defects.
Yield:	The ratio of usable units at the end of a manufacturing process to the number of parts initially submitted.

MODEL 165-XXXX

Custom Hybrid
Military Grade
Microcircuit



DESCRIPTION

Hybrid microcircuits offer a reliable, cost effective alternative to larger and heavier circuit boards and to the costly design effort and implementation of a custom IC. Hybrids also offer the advantage of a much broader combination of components and resistor technologies. Generally, a circuit board schematic can be directly converted to hybrid technology with little or no change in component selection.

The implementation of a custom hybrid requires a partnership between the customer and BI. A project engineer and a program manager work with you throughout the design and manufacturing cycle.

BI specialist will assist in proper package and process selection to meet your environmental requirements. Our design engineers will develop a CAD layout design and the documents required for proper manufacturability. Our quality assurance personnel will develop appropriate inspection and qualification plans.

Our hybrids consist of a ceramic substrate on which multiple layers of gold conductors, resistive inks and insulative materials are screened. Components are then epoxy mounted to the substrate. Semiconductors are wire bonded with gold and aluminum bonds. The substrate is then placed into a package and affixed with an epoxy preform. The package is sealed, marked and subjected to various environmental screens as required to meet customer specifications. All parts are 100% electrically tested over the operating temperature range using our custom automated test system.

The microcircuit operation quality system is designed to meet ISO9001 and MIL-H-38534. BI is fully certified to MIL-STD-1772 and has been listed on QML-38534 since 1989.

7

FEATURES

- Fully customized circuit and package
- Wide package variety
- Thick film and thin film technology
- MIL-STD-1772 certified
- Reduced package size
- Improved circuit performance
- Improved reliability

TYPICAL APPLICATIONS

- Analog signal conditioning
- Instrumentation amplifier
- Power amplifier
- Data acquisition
- Data convertors
- Line driver/receiver
- Analog switching
- DC/DC convertor

ELECTRICAL

Thick Film Resistors:	
Absolute Accuracy	to 0.5%
Temperature Coefficient of Resistance	±50ppm/°C to ±200ppm/°C
Temperature Coefficient of Resistance Tracking	±10ppm/°C
Thin Film Resistors:	
Absolute Accuracy	to 0.1%
Temperature Coefficient of Resistance	±5ppm/°C to ±50ppm/°C
Temperature Coefficient of Resistance Tracking	±2ppm/°C
Operating Temperature Range	-55°C to +125°C
Functional Trimming	Circuit accuracies can be tightened on some parameters by performing active functional trimming on resistor elements

COMPONENT TECHNOLOGIES

Semiconductor Components	All transistors & diodes in die form
Integrated Circuits	IC or ASIC in die form
Capacitors	Ceramic chip, tantalum chip and bondable MOS capacitors
Other Components	Wide range of components including inductors, transformers, crystals, etc

MECHANICAL

Substrate	Alumina (beryllia also available)
Interconnect Layers	1 to 6
Interconnect Material	Gold or palladium silver
Die Attach	Epoxy (solder, eutectic also available)
Package Construction	Metal with glass insulated feedthroughs and cofired ceramic

PACKAGING

Package Size	A wide variety of custom packaging from 0.25" to 3.0" on a side
Package types	Metal (seam weld), metal (solder seal), ceramic (seam weld),ceramic (solder seal), ceramic (epoxy seal) and polymer encapsulated (PEP)
Package configurations	SIP, DIP, Plug-in (platform or sidewall),Planar (flatpack) and LCC

QUALITY

In-line QCI

Qualifications to MIL-STD-1772

ORDERING INFORMATION

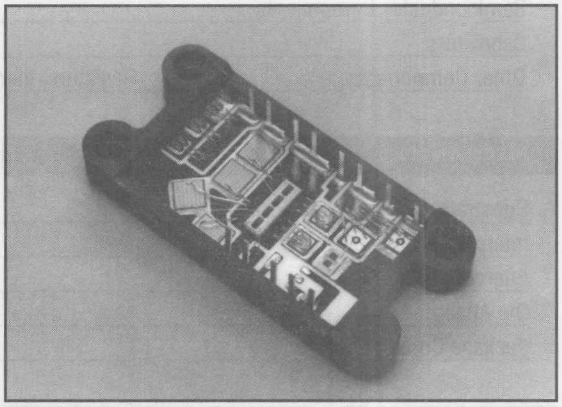
During the proposal phase, a customer interface will be set up to develop and price alternate design approaches. A schematic with basic dimensional and environmental requirements are sufficient at this stage.

ENVIRONMENTAL

Environmental screens include, but are not limited to MIL-STD-883 such as: leak test, centrifuge, temperature cycling, burn-in and stabilization bake.

MODEL 170-XXXX

Custom Power Modules



DESCRIPTION

BI's Custom Power Modules are designed to assemble all of your circuit's power components into one, easy to manage, package. Power modules offer a low cost method to improve the circuit density. These modules will also reduce the assembly labor by eliminating insulating pads and reducing the individual bolting of discreet power semiconductors. BI offers power module designs that allow the module to be soldered to the circuit board at the same time as the other components, eliminating hand soldering operations. Power modules allow the use of a simpler and less expensive heat sink.

All the power components normally bolted to the heat sink should be included in the custom module. Snubbers, gate resistors, FET drivers, temperature sensors and other support circuitry can also be included.

PACKAGING

Package Size:	A wide variety of custom packaging from 0.3" to 4.0" on a side.
Package (typical):	Heat sink attachment and heat transfer.
Package configurations:	Ceramic substrate, typically copper clad to promote heat transfer.The base, with mounted components, is assembled into a custom frame and encapsulated.

7

FEATURES

- Low cost custom modules
- Reduced circuit size
- Allows simplified heat sink
- Soldering technique minimizes voids
- Flexible package dimensions

TYPICAL APPLICATIONS

- Power supply subassemblies
- Motor driver
- Power amplifier
- H-Bridge
- Bridge rectifier
- Ganged power fets

ELECTRICAL

Semiconductor Components	BJTs, FETs, Diodes, SCRs, IGBTs
Capacitors	Ceramic and tantalum
Other Components	Resistors, thermisters and various surface mount/solder mount components

MECHANICAL

Substrate	Alumina, beryllia, aluminum nitride, aluminum, copper
Interconnect Layers	1 (crossover layers possible)
Interconnect Material	Copper
Die Attach	Solder attached, aluminum & gold wire bonding
Package Construction	Substrate base with plastic frame

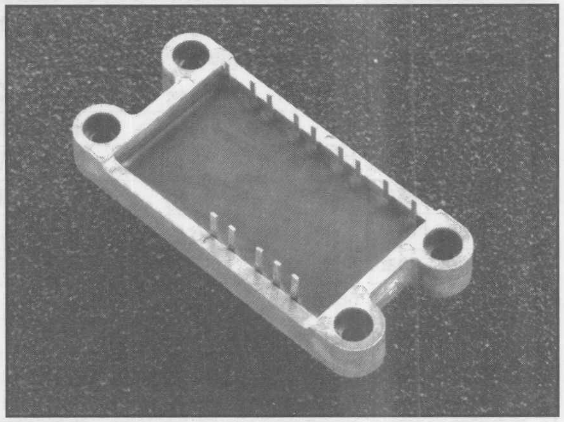
ENVIRONMENTAL

Custom power modules are typically designed to operate over a temperature range of -55°C to +125°C.

MODEL 7700

Power Factor Correction

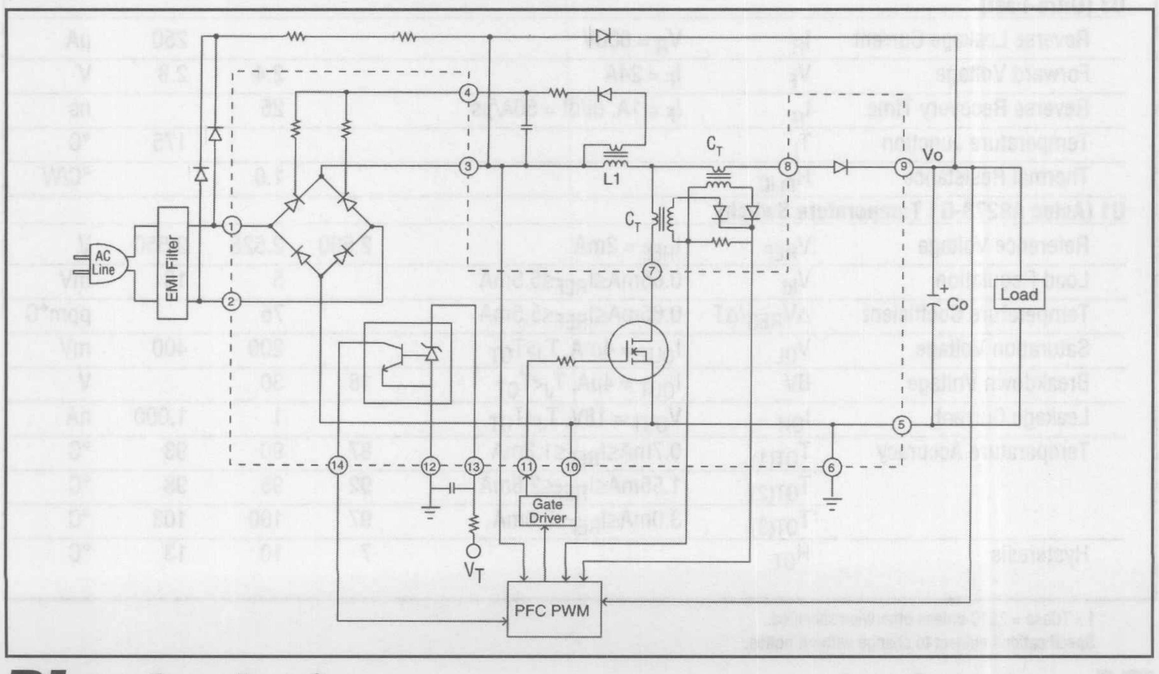
Power Module



Model 7700 is designed to optimally facilitate a 20 Amp boost type power factor correction (PFC) system.

- Module contains all power components necessary to build a power supply front end.
  - Rectifier bridge with SCRs for in rush current limiting
  - Ultra fast 24 Amp output diode
  - Temperature sensing switch
  - 500V .1Ω FET
- Provides optimum use of available line current.
- Allows power supply to meet requirements of IEC 555-2.
- Reduces cost of heat sink.
- Saves significant space and assembly time.
- Custom versions available to meet specific requirements.

TYPICAL APPLICATION



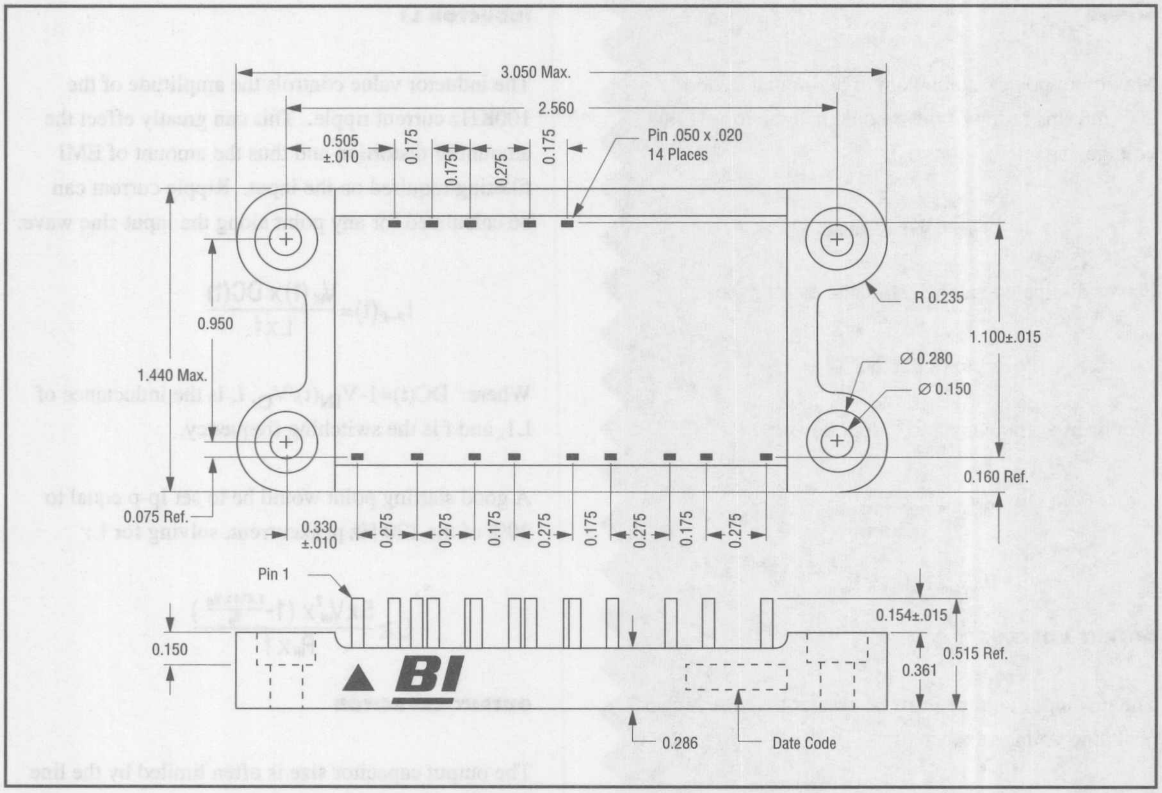
7

ELECTRICAL CHARACTERISTICS

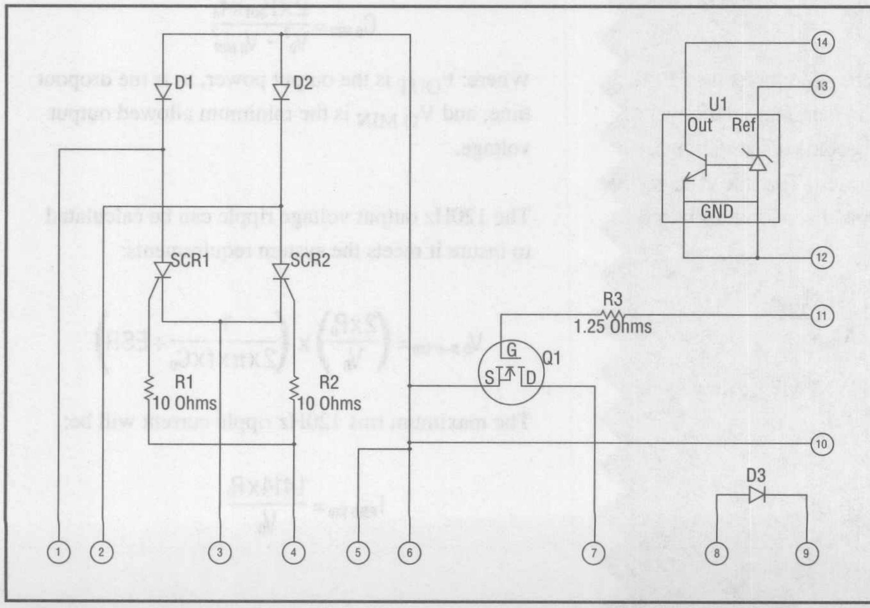
Parameter	Symbol	Conditions[1]	Min	Typ	Max	Units
Q1 (n-Channel Enhancement Mode FET)						
Drain Leakage Current	I_{DSS}	V_{DS} = 500V, V_{GS} = 0V			1.0	mA
On-State Voltage	$V_{DS(on)}$	I_{DS} = 28A, V_{GS} = 10V		2.6	2.8	V
Threshold Voltage	$V_{GS(th)}$	V_{DS} = 4V, I_{DS} = 1mA	2.0	3.0	4.0	V
Gate Leakage Current	I_{GSS}	V_{GS} = ±15V, V_{DS} = 0V			±400	nA
Diode Forward Voltage	V_{SD}	I_S = 50A, V_{GS} = 0V		.95	1.5	V
Input Capacitance	C_{iss}	V_{GS} = 0V, V_{DS} = 25V, f = 1.0MHz		12		nF
Junction Temperature	T_j				150	°C
Thermal Resistance	R_{thJC}			0.25		°C/W
SCR1 and SCR2						
Reverse Leakage Current	I_{ROM}	V_{ROM} = 600V			25	μA
Forward Blocking Current	I_{FSM}	V_{FSM} = 600V			25	μA
Forward On Voltage	V_F	I_F = 25A, I_G = 60mA		1.3	1.6	V
Gate Trigger Voltage	V_{GT}	V_A = 12V, R_L = 100Ω		1.4	2.0	V
Gate Trigger Current	I_{GT}	V_A = 12V, R_L = 100Ω		40	60	mA
Junction Temperature	T_j				125	°C
Thermal Resistance	R_{thJC}			1.4		°C/W
D1 and D2 (Standard Recovery)						
Reverse Leakage Current	I_R	V_R = 600V			100	μA
Forward Voltage	V_F	I_F = 25A		1.0	1.2	V
Temperature Junction	T_j				150	°C
Thermal Resistance	R_{thJC}			1.8		°C/W
D3 (Ultra-Fast)						
Reverse Leakage Current	I_R	V_R = 600V			250	μA
Forward Voltage	V_F	I_F = 24A		2.4	2.8	V
Reverse Recovery Time	t_{rr}	I_F = 1A, di/dt = 50A/μs		25		ns
Temperature Junction	T_j				175	°C
Thermal Resistance	R_{thJC}			1.0		°C/W
U1 (Astec AS273-G1 Temperature Switch)						
Reference Voltage	V_{REF}	I_{REF} = 2mA	2.500	2.525	2.550	V
Load Regulation	V_{ld}	0.65mA≤I_{REF}≤5.5mA		5	10	mV
Temperature Coefficient	$\Delta V_{REG}/\Delta T$	0.65mA≤I_{REF}≤5.5mA		75		ppm°C
Saturation Voltage	V_{OL}	I_{OUT} = 4mA, T_J>T_{OT}		200	400	mV
Breakdown Voltage	BV	I_{OUT} = 4μA, T_J<T_{OT}	18	30		V
Leakage Current	I_{OH}	V_{OUT} = 18V, T_J<T_{OT}		1	1,000	nA
Temperature Accuracy	$T_{OT(1)}$	0.7mA≤I_{REF}≤1.3mA	87	90	93	°C
	$T_{OT(2)}$	1.55mA≤I_{REF}≤2.6mA	92	95	98	°C
	$T_{OT(3)}$	3.0mA≤I_{REF}≤5.0mA	97	100	103	°C
Hysteresis	H_{OT}		7	10	13	°C

1 - TCase = 25°C unless otherwise specified.
Specifications subject to change without notice.

OUTLINE DIMENSIONS



SCHEMATIC



Pin Designation

Pin 1: AC1
Pin 2: AC2
Pin 3: Bridge Output
Pin 4: SCR Gates
Pin 5: Ground
Pin 6: Ground
Pin 7: FET Drain
Pin 8: Ultra Fast Anode
Pin 9: Ultra Fast Cathode
Pin 10: Gate Ground
Pin 11: Gate Drive
Pin 12: Thermal Switch Ground
Pin 13: Thermal Switch V_{ref}
Pin 14: Thermal Switch V_{out}

7

POWER

Maximum power available will be limited by the 20 Amp rms rating of the module and the lowest line voltage expected:

$$P_{IN\ MIN} = V_{IN\ MIN} \times I_{IN\ MAX}$$

Power dissipated can be estimated as follows:

$$P_D = 4 \times I_{IN} + .3 \times I_{IN}^2$$

Worst case efficiency and output power:

$$eff_{WC} = \frac{P_{IN\ MIN} - P_D}{P_{IN\ MIN}}$$

$$P_{OUT\ WC} = eff_{WC} \times P_{IN\ MIN}$$

OUTPUT VOLTAGE

The dc output voltage must be greater than the highest peak line voltage expected:

$$V_O > V_{IN\ MAX} \times 1.414$$

DISCONTINUOUS CONDUCTION

When the line voltage approaches zero volts the PFC PWM will be forced towards its maximum duty cycle. This will cause the current to become discontinuous, which will result in some distortion. The line voltage at which the current will become discontinuous will be:

$$V_{IN\ discontinuous} = \frac{V_O \times (1 - DC_{MAX})}{DC_{MAX}}$$

The line voltage at which the PWM will be duty cycle limited will be:

$$V_{IN\ duty\ cycle\ limited} = V_O \times (1 - DC_{MAX})$$

INDUCTOR L1

The inductor value controls the amplitude of the 100KHz current ripple. This can greatly effect the amount of distortion and thus the amount of EMI filtering required on the input. Ripple current can be calculated for any point along the input sine wave:

$$I_{P-P}(t) = \frac{V_{IN}(t) \times DC(t)}{L \times f}$$

Where: $DC(t)=1-V_{IN}(t)/V_O$, L is the inductance of L1, and f is the switching frequency.

A good starting point would be to set Ip-p equal to 20% of the 120 Hz peakcurrent, solving for L:

$$L \geq \frac{5 \times V_{IN}^2 \times (1 - \frac{1.414 \times V_{IN}}{V_O})}{P_{IN} \times f}$$

OUTPUT CAPACITOR

The output capacitor size is often limited by the line dropout requirements of the power supply:

$$C_{O\ MIN} = \frac{2 \times P_{OUT} \times t_d}{V_O^2 - V_{O\ MIN}^2}$$

Where: P_{OUT} is the output power, td is the dropout time, and $V_{O\ MIN}$ is the minimum allowed output voltage.

The 120Hz output voltage ripple can be calculated to insure it meets the system requirements:

$$V_{O\ P-P\ 120} = \left(\frac{2 \times P_O}{V_O}\right) \times \left(\frac{1}{2 \times \pi \times f \times C_O} + ESR\right)$$

The maximum rms 120Hz ripple current will be:

$$I_{RMS\ 120} = \frac{1.414 \times P_O}{V_O}$$

The 100KHz output voltage ripple will be:

$$V_{O\ P\text{-}P\ 100K} = \frac{V_{IN} \times \left(1 - \frac{(1.414 \times V_{IN})}{V_O}\right)}{L \times f} \times \left(\frac{1}{2 \times \pi \times f \times C_O} + ESR \right)$$

The maximum rms 100KHz ripple current will be:

$$I_{RMS\ 100K} = \frac{V_{IN} \times \left(1 - \frac{1.414 \times V_{IN}}{V_O}\right)}{2.828 \times L \times f}$$

GATE DRIVE REQUIREMENTS

FET switching times must be fast enough to insure that the FET turns off when the PWM is at maximum duty cycle. Snubbing circuits across the FET will slow the turn off time and should not be used.

A discrete gate driver circuit will allow the fastest possible switching times. The Unitrode UC3710 or Teledyne TC4422 drivers offer a single chip approach with only slightly slower switching times. The gate driver must be located as close to the module as possible. Ground sense pin 10 should be used to insure the fastest possible switching times.

HEAT RADIATOR

The heat radiator requirements can be determined by the maximum power dissipated (at low line) and the maximum ambient temperature. The back side of the module will be limited to about 85°C by the thermal switch.

$$R_{\Theta} = \frac{85 - T_{MAX\ AMB}}{P_{O\ LOWLINE}}$$

Care should be used when attaching the module to the heat radiator. The screws must be tightened incrementally in a crisscross pattern. A torque limiting screwdriver should be used.

The high current levels require currrent sense transformers to maintain a reasonable efficiency. We recommend BI Technologies HM31-20200.

PFC PWM VENDORS

Popular sources are: Unitrode UC3854, Micro Linear ML4812, and Linear Technology LT1248.

THERMAL SWITCH

This module uses a programmable solid state temperature sensing IC with an open collector output. Astec Semiconductor's AS273 can be configured to shut down the supply when the temperature threshold is reached. The programming resistor and a .1µF ceramic capacitor should be located as close to the module as possible to eliminate any EMI problems. The AS273 can also be configured as a dual speed fan control, and as a three state temperature warning sensor. For more information contact Astec Semiconductor, 255 Sinclair Frontage Road, Milpitas CA 95035, Tel (408) 263-8300, Fax (408) 263-8340.

The high current levels require current sense transformers to maintain a reasonable efficiency. We recommend BI Technologies HM21-20200.

[illegible]

[illegible] BI Technologies [illegible]

[illegible]

This module uses a [illegible] temperature sensing [illegible] output. [illegible] shut down the supply when the temperature threshold is reached. The programming resistor and a [illegible] ceramic capacitor should be located as close to [illegible] module as possible to eliminate any [illegible]. The [illegible] can also be configured as a dual speed fan controller and a three state temperature [illegible] sensor. For more information contact [illegible] Semiconductor, 255 [illegible] [illegible]

MODEL 7710-X

Power Factor Correction

Power Module

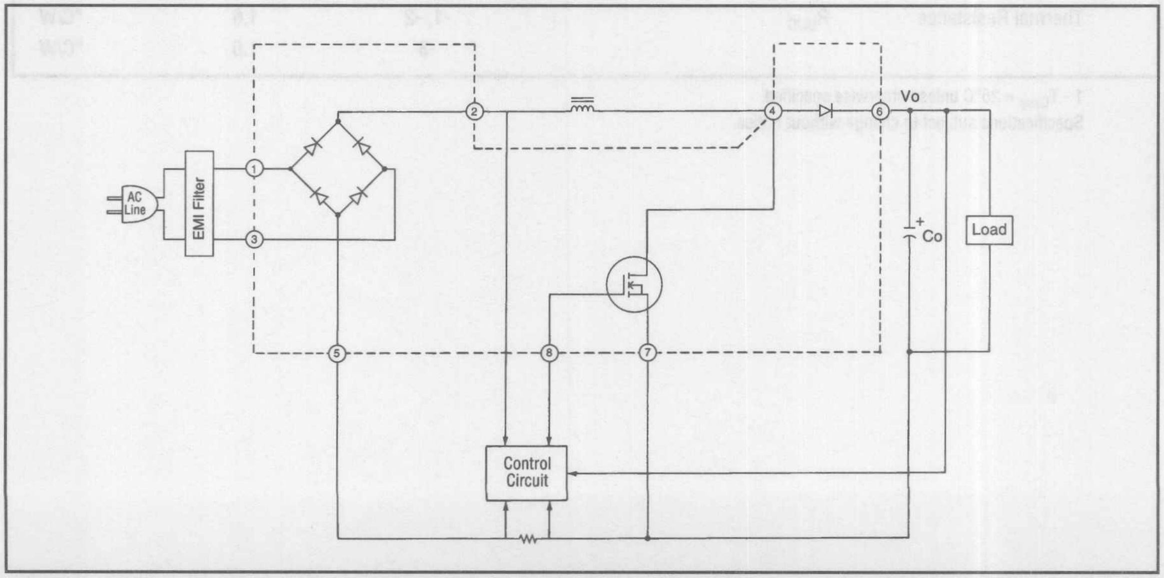
New Product Preliminary Data

Model 7710 is designed to optimally facilitate a boost type power factor correction (PFC) system, for designs from 500W through 1200W.

- Module contains all power components necessary to build a power supply front end.
  - Rectifier bridge
  - Ultra fast output diode
  - 500V .12Ω FET
- Provides optimum use of available line current
- Allows power supply to meet requirements of IEC 555-2
- Reduces cost of heat sink
- Saves significant space and assembly time
- Custom versions available to meet specific requirements

7

TYPICAL APPLICATION

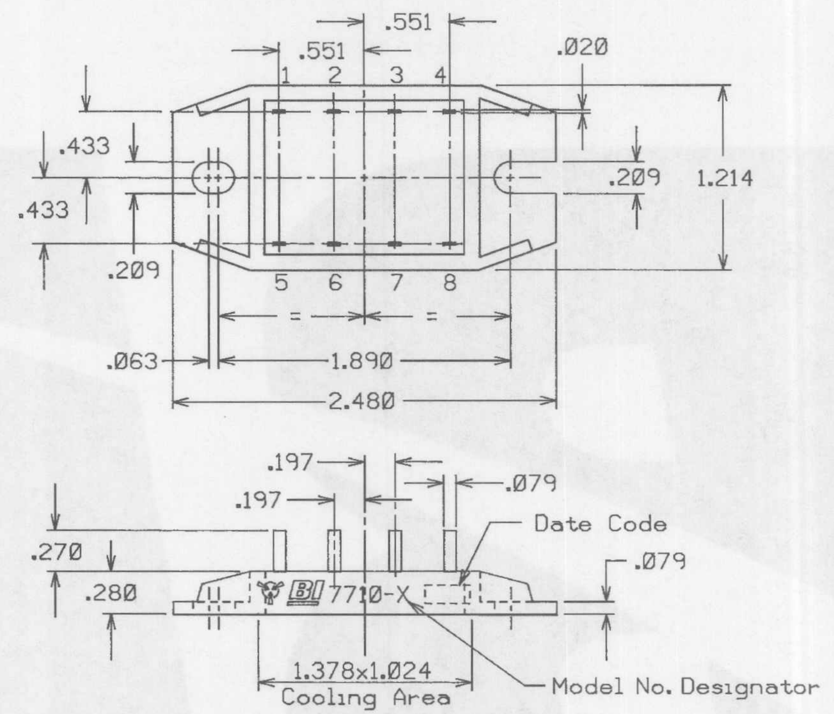


ELECTRICAL CHARACTERISTICS

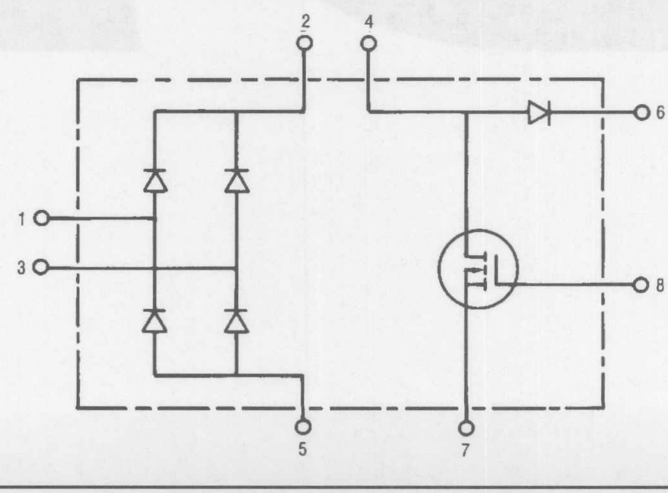
Parameter	Symbol	Conditions[1]	7710-X	Min	Typ	Max	Units
Q1 (n-Channel Enhancement Mode FET)							
Drain Leakage Current	I_{DSS}	V_{DS} = 500V, V_{GS} = 0V	-1			500	uA
			-2, -3			750	uA
On-State Voltage	$V_{DS(on)}$	I_{DS} = 14A, V_{GS} = 10V	-1		2.6	2.8	V
		I_{DS} = 21A, V_{GS} = 10V	-2, -3		2.6	2.8	V
Threshold Voltage	$V_{GS(th)}$	V_{DS} = 4V, I_{DS} = 1mA		2.0	3.0	4.0	V
Gate Leakage Current	I_{GSS}	V_{GS} = ±15V, V_{DS} = 0V	-1			±200	nA
			-2, -3			±300	nA
Diode Forward Voltage	V_{SD}	I_S = 25A, V_{GS} = 0V	-1			1.5	V
		I_S = 38A, V_{GS} = 0V	-2, -3			1.5	V
Input Capacitance	C_{iss}	V_{GS} = 0V, V_{DS} = 25V,	-1		6		nF
		f = 1.0MHz	-2, -3		9		nF
Junction Temperature	T_j					150	°C
Thermal Resistance	R_{thJC}		-1		0.50		°C/W
			-2		0.33		°C/W
			-3		0.18		°C/W
Diode Bridges							
Reverse Leadage Current	I_R	V_R = 800V				100	µA
Forward Voltage	V_F	I_F = 20A				1.2	V
Junction Temperature	T_j					150	°C
Thermal Resistance	R_{thJC}		-1, -2		1.8		°C/W
			-3		1.1		
Ultra-Fast Diode							
Reverse Leakage Current	I_R	V_R = 600V				250	µA
Forward Voltage	V_F	I_F = 15A				2.8	V
Reverse Recovery Time	t_{rr}	I_F = 1A, di/dt = 50A/µs			35		ns
Junction Temperature	T_j					175	°C
Thermal Resistance	R_{thJC}		-1, -2		1.6		°C/W
			-3		1.0		°C/W

1 - T_{Case} = 25°C unless otherwise specified.
Specifications subject to change without notice.

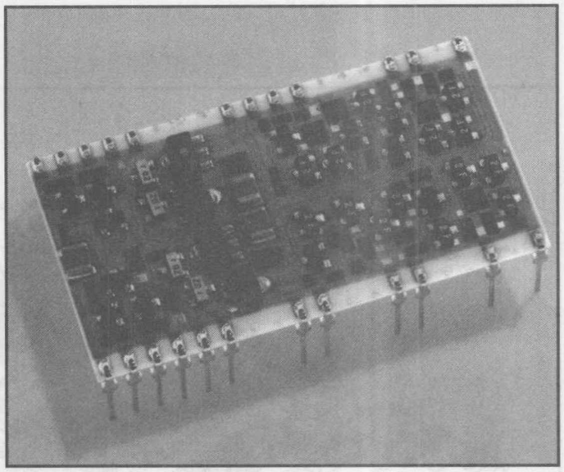
OUTLINE DIMENSIONS (INCH)



SCHEMATIC



COMMERCIAL HYBRIDS



BI Technologies' commercial hybrids offer you a better approach to surface mounted electronic subassemblies.

FEATURES

- Low Cost Surface Mount Assembly
- Chip on Board Capability
- Reduced Board Size
- Ceramic Board
- Integral Thick Film Resistors
- U.S. Design & Management
- U.S. or Offshore Assembly
- Versatile Lead Configuration
- Low Profile Outline

DESCRIPTION

Whether you are upgrading your "through-hole" circuit board to surface mount or developing a new design, BI Technologies has the solution for you.

BI commercial hybrids can be used as subassemblies on a motherboard, or they can encompass your entire circuit.

Hybrid assemblies are being used in an increasing number of applications. Our commercial hybrids are circuit boards based on ceramic material rather than conventional Polymer materials. In small- to mid-sized assemblies, ceramic substrates offer price-competitive solutions and many quality and design advantages.

Resistors are directly screened onto the substrate and other components are typically surface mounted. Chip and wire attachment is available for components where required. A variety of lead frame configurations are available to create SIP's, DIP's, through hole, and surface mountable assemblies. Glop topping or polymer encapsulation can be used to protect components and proprietary designs.

IMPLEMENTATION

BI has an experienced design team that provides customer assistance on new programs from the proposal/estimate phase through development and into production.

During the proposal phase, a customer interface will be set up to develop and price alternate design approaches. During the development phase, a close working arrangement will be maintained through prototype samples and into production.

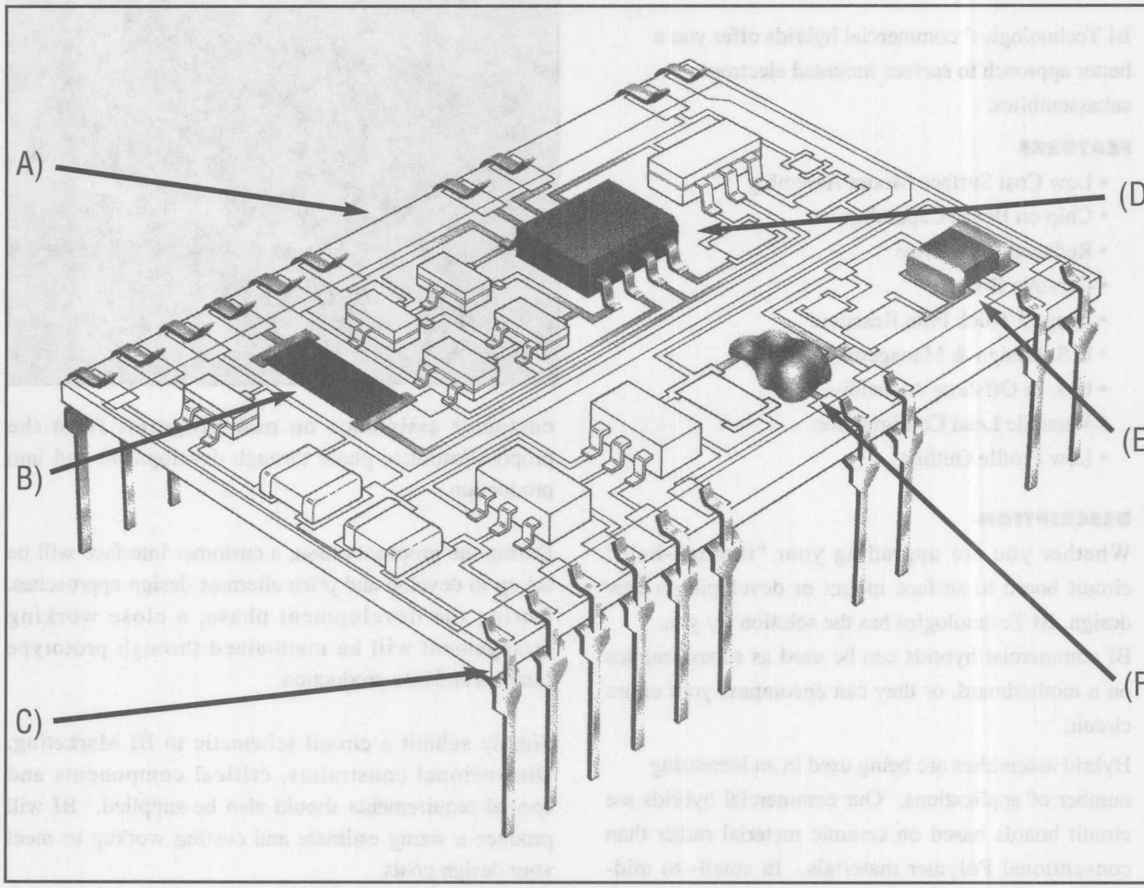
Simply submit a circuit schematic to BI Marketing. Dimensional constraints, critical components and special requirements should also be supplied. BI will produce a sizing estimate and costing workup to meet your design goals.

COMMITMENT

BI is committed to servicing your needs. BI has been a dominant force in the commercial and military hybrid microelectronics industry since its conception. Our reputation is built on over 25 years of proven reliability and quality. BI's Program Management, Engineering group and Quality Department are located in Fullerton, California for ease of contact and interface. BI's domestic location is your window to global facilities. BI Fullerton can draw on multiple factory locations, including Mexico, Scotland, Asia and Fullerton, to select the optimum resources for your assembly needs.

The Surface Mount Advantage . . .

– *Low cost, high quality*



CERAMIC BOARD (A)

Our hybrids use ceramic (alumina) substrates to achieve optimum size reduction and reliability. Ceramic substrates produce an environmentally superior product. The advantages of ceramic over polymer board construction include: better heat dissipation, elimination of blistering, minimal moisture absorption, reduced size and improved performance. For small-sized assemblies (up to approx. 2" x 2"), ceramic board construction is usually the low cost choice. Thick film conductors, typically Palladium silver or gold, as small as 5 mil wide, are screened onto the substrate. Multilayer construction of up to five metal layers is standard.

PRECISION SCREENED RESISTORS (B)

Thick film resistors are screened directly onto the substrate utilizing a wide range of resistor inks, yielding high precision at low cost. Our thick film resistors can be ratio matched to 0.1% with absolute tolerances of 0.5%. Thick film resistors can be located underneath surface mount devices, or screened onto the back of the substrate for increased circuit densities.

INTERCONNECT FLEXIBILITY (C)

Lead frames can be attached to accommodate a variety of interconnection requirements. Leads can be affixed to any or all edges of the substrate and can be configured for various mounting styles. Additionally, a wide variety of standard sockets can be attached to allow plug-in capability to your next level of assembly.

SURFACE MOUNT SEMICONDUCTORS (D)

BI has experience with a wide range of surface mountable semiconductors in packaged configurations, including SOT, SO, SOL and PLCC. Our commercial hybrids will also accommodate semiconductor die attached and wire bonded directly to the substrate. This allows us to utilize ASICs and other semiconductors not currently offered in a surface mountable package.

SURFACE MOUNT PASSIVE COMPONENTS (E)

Ceramic and tantalum capacitors, chip inductors and resistor chips all lend themselves to surface mount assembly. Axial leaded components can be formed and mounted as well.

ENCAPSULATION (F)

Surface mount hybrids do not normally require encapsulation. However, encapsulation may be applied if desired for rigidity or for protection of proprietary circuit design. When chip and wire elements are used, these are generally individually "glob-topped" to provide protection for the device; the entire module may then be fully encapsulated.

Application Notes
Hybrid Microcircuits

7

POWER FACTOR CORRECTION

INTRODUCTION

Modern electronic equipment can create noise that will cause problems with other equipment on the same supply system. To reduce system disturbances it is therefore essential to correct for this, which requires an understanding of the problems poor power factors can cause, the requirements of correcting the power factor, and the methods of power factor correction.

WHAT IS POWER FACTOR?

A resistive load is ideal for an ac source. It will draw current from the ac line in a sine wave that is in phase with the line voltage. The classical definition of power factor is:

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{input voltage x input current}}$$

The real power is expressed in watts. The rms voltage multiplied by the rms current is expressed in volt-amps-reactive (VA or VAr).

Power factor is a unit-less number between 1 and 0, where a power factor of 1 would indicate the current and voltage are exactly in phase. The power factor for a linear load is the cosine of the phase angle.

A resistive load will have a power factor of 1. The power factor for an inductive load will be less 1 because the current will lag behind the voltage.

Wiring, circuit breakers, and transformers that are used to supply power must be appropriately sized to the VA rating of the load. The power factor of an inductive load can be improved by adding a proportional amount of capacitance across it. This will counteract the inductance and a power factor of 1 can be achieved.

Most modern equipment uses a switch mode power supply to convert the high voltage ac to lower dc voltages. These power supplies use a rectifier and capacitor connected in series to the ac line, see **Figure 1**. This nonlinear load on the ac line causes large peak currents at the peaks of the ac line voltage. This can cause the line voltage to be clipped at the peak, see **Figure 2**. The wiring, circuit breakers, and transformers must therefore be rated to handle the large peak current. The current will be almost in phase with the voltage, but the current will not be sinusoidal. The modern definition of power factor uses only the first or fundamental harmonic of the line current for the real power calculation.

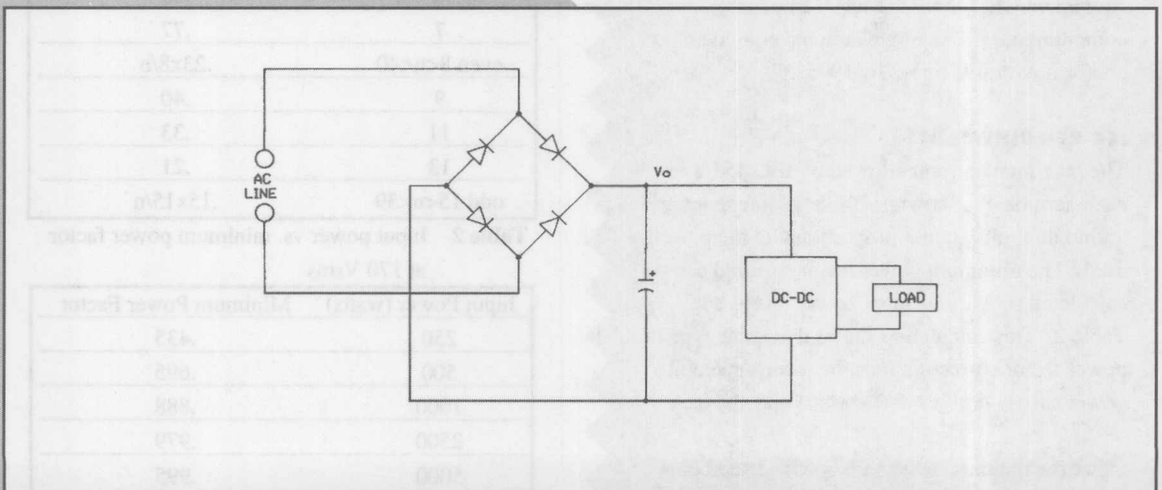


FIGURE 1: Typical switch mode power supply circuit

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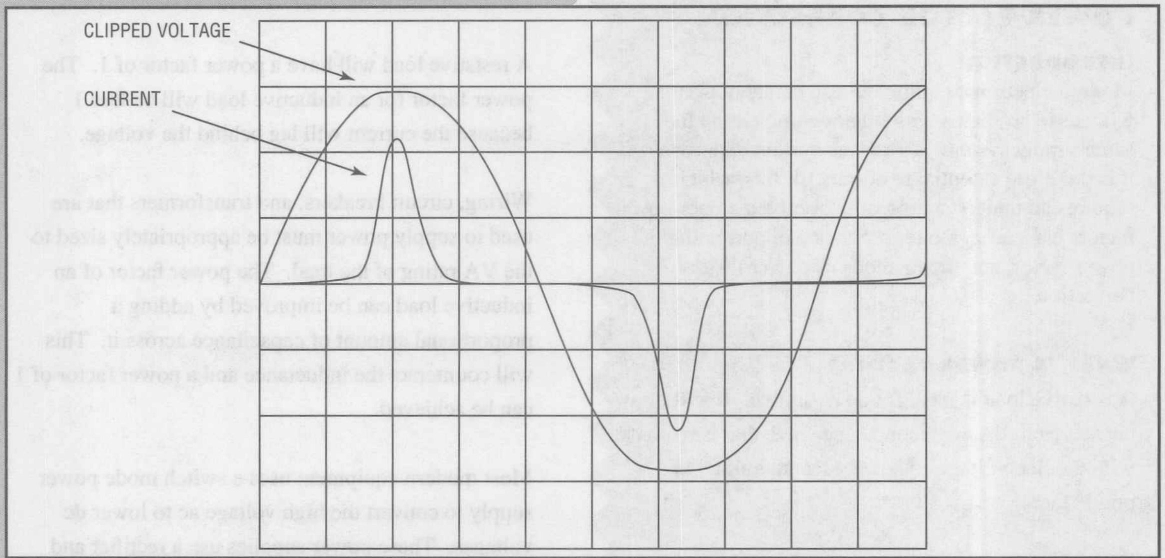


FIGURE 2: Typical wave forms for a switch mode power supply

The power factor of most off line switch mode power supplies is about 0.65.

The high peak currents and clipping of the voltage can cause problems for other equipment connected to the supply system. These problems are so prevalent with today's electronic equipment that the International Electrotechnical Commission (IEC) found it necessary to regulate the current harmonics of household appliances and similar electrical equipment (IEC 555-2). Most European communities will require electronic equipment to conform with IEC 555-2 by 1995.

IEC REQUIREMENTS

The maximum current allowed by IEC 555-2 for each harmonic is shown in Table 1, note that the harmonic limits are not proportional to the power used. The minimum power factor required can be calculated for various input power levels, see Table 2. This calculation shows that some type of power factor correction must be incorporated in power supply designs at 500 watts and above.

Other regulations, such as EN60555-2, are being considered and may impose a mA/watt specification that would require a power factor greater than 0 .7 for all equipment regardless of input power.

Table 1 IEC 555-2 Harmonic current limits

Harmonic	Maximum Current (amperes)
2	1.08
3	2.30
4	.43
5	1.14
6	.30
7	.77
even 8<n<40	.23x8/n
9	.40
11	.33
13	.21
odd 15<n<39	.15x15/n

Table 2 Input power vs. minimum power factor at 170 Vrms

Input Power (watts)	Minimum Power Factor
250	.435
500	.695
1000	.888
2500	.979
5000	.995

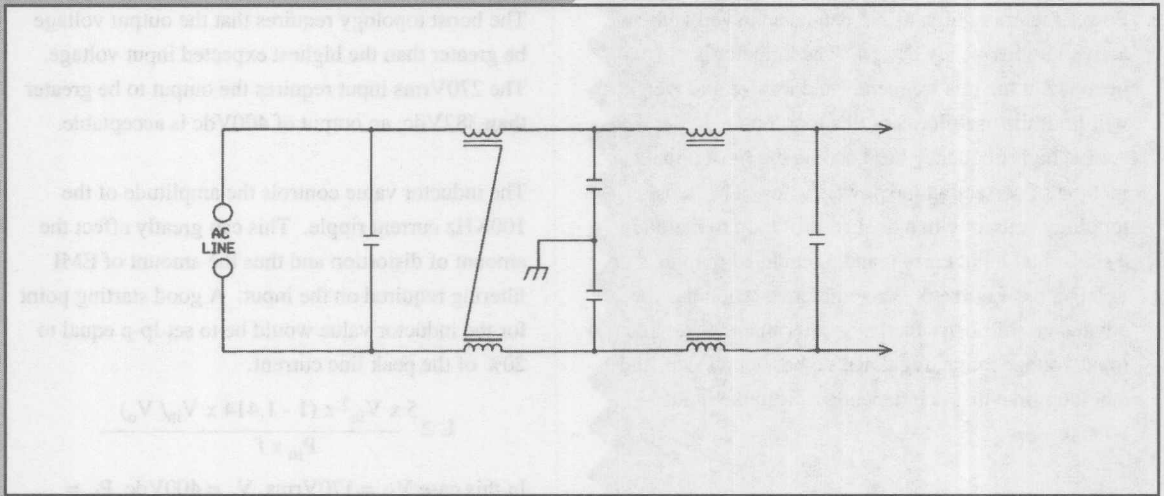


FIGURE 3: For typical passive input filter

POWER FACTOR CORRECTION METHODS

Passive input filtering can achieve a .7 power factor for power levels below 500 watts. **Figure 3** shows a typical circuit. Each design will require unique values for the inductors and capacitors. This filter will operate at the line frequency and will require relatively large inductors and capacitors. A passive filter would be too large and heavy for most designs above 500 watts or with power factors greater than .7. An active low frequency approach can be implemented up to about 1000 watts. **Figure 4** shows a typical design and the current wave form.

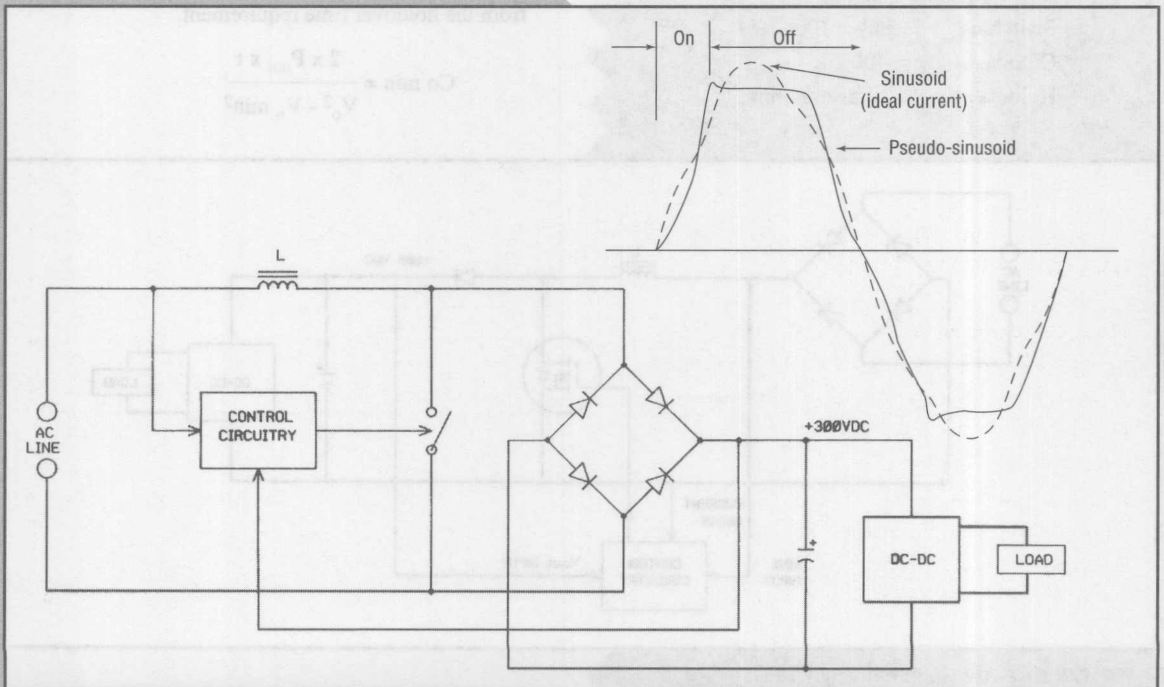


FIGURE 4: Active low frequency PFC

Power factors as high as .95 can be achieved with an active low frequency design. The inductor is operated at the line frequency and its size and weight will limit the usefulness of this topology.
Active high frequency has become the most popular method of correcting the power factor. The boost topology is used with a dual control loop to maintain a sinusoidal input current and a regulated output voltage, see **Figure 5**. This implementation has the advantages of power factors greater than .99, a wide input voltage range, regulated dc bus, small size, and a holdup time that is independent from the input voltage.

ACTIVE HIGH FREQUENCY EXAMPLE

The following specifications are used for a design example of an active high frequency power factor corrected front end.

Maximum output power = 3000 watts
Input voltage range = 170 - 270 Vrms
Line frequency = 47 - 65 Hz
Switching frequency = 100KHz
Output voltage = 400Vdc
Holdover time = 30ms minimum

The boost topology requires that the output voltage be greater than the highest expected input voltage. The 270Vrms input requires the output to be greater than 382Vdc, an output of 400Vdc is acceptable.

The inductor value controls the amplitude of the 100KHz current ripple. This can greatly affect the amount of distortion and thus the amount of EMI filtering required on the input. A good starting point for the inductor value would be to set Ip-p equal to 20% of the peak line current.

$$L \geq \frac{5 \times V_{in}^2 \times (1 - 1.414 \times V_{in} / V_o)}{P_{in} \times f}$$

In this case V_{in} = 170Vrms, V_o = 400Vdc, P_{in} = 3400 watts, and f = 100KHz. The inductor must be greater than 170uH while allowing for operation into saturation. A Micrometals E220-18 core with 48 turns of two #16 wires will provide a conservative choice for the inductor.

The value of the output capacitor can be determined from the holdover time requirement.

$$\text{Co min} = \frac{2 \times P_{out} \times t}{V_o^2 - V_o \text{ min}^2}$$

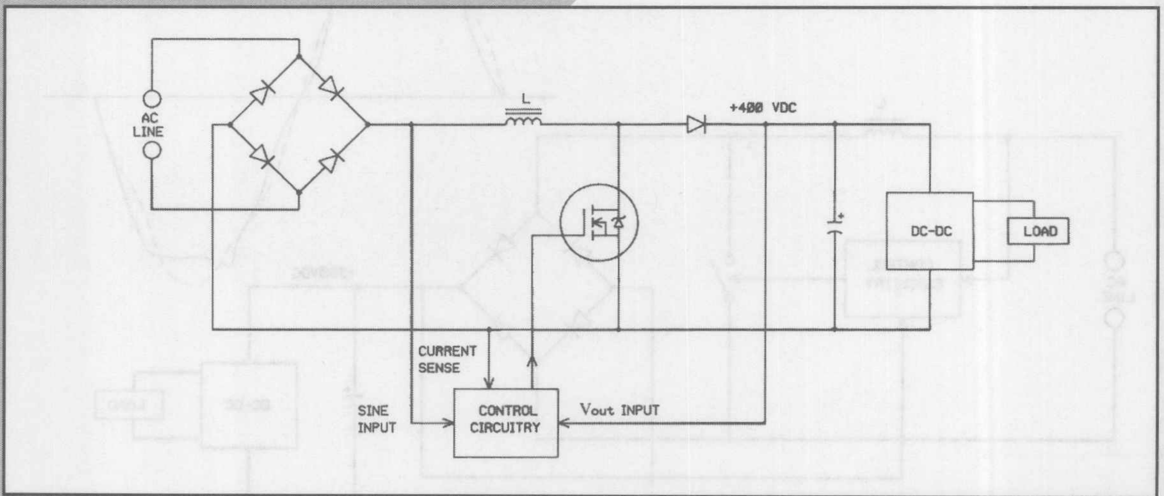


FIGURE 5: Active high frequency PFC

Assuming the load will be dc-dc converters that can maintain their outputs with a minimum input voltage of 240Vdc, then the output capacitance should be 1800uF. Four United Chemi-Con 35x50 450V 470uF capacitors would suffice.

A power module that contains all the power semiconductors needed to implement this circuit at currents up to 20Arms has been developed by BI Technologies. This module, model 7700, contains a rectifier bridge with SCRs to limit the inrush current, an ultra fast 24 amp output diode, a temperature sensing switch, and a 500V .1ohm FET. This module significantly reduces the labor involved with mounting the components to the heat sink, simplifies the design, and saves space. **Figure 6** shows a schematic of the module.

Several IC manufacturers offer a control chip specifically for active high frequency power factor correction. Linear Technology, Micro Linear, and Unitrode are popular sources. These manufactures have detailed data sheets and application notes that delineate how to utilize their ICs.

FET switching times must be fast enough to insure that the FET turns off when the PWM is at maximum duty cycle. A gate driver such as the Teledyne TC4422 or a similar discrete design must be used.

The air flow and heat sink design must be sufficient to keep the inductor and power module within their rated temperatures. The power module contains a thermal switch that can be used to shut down the supply in case of over temperature.

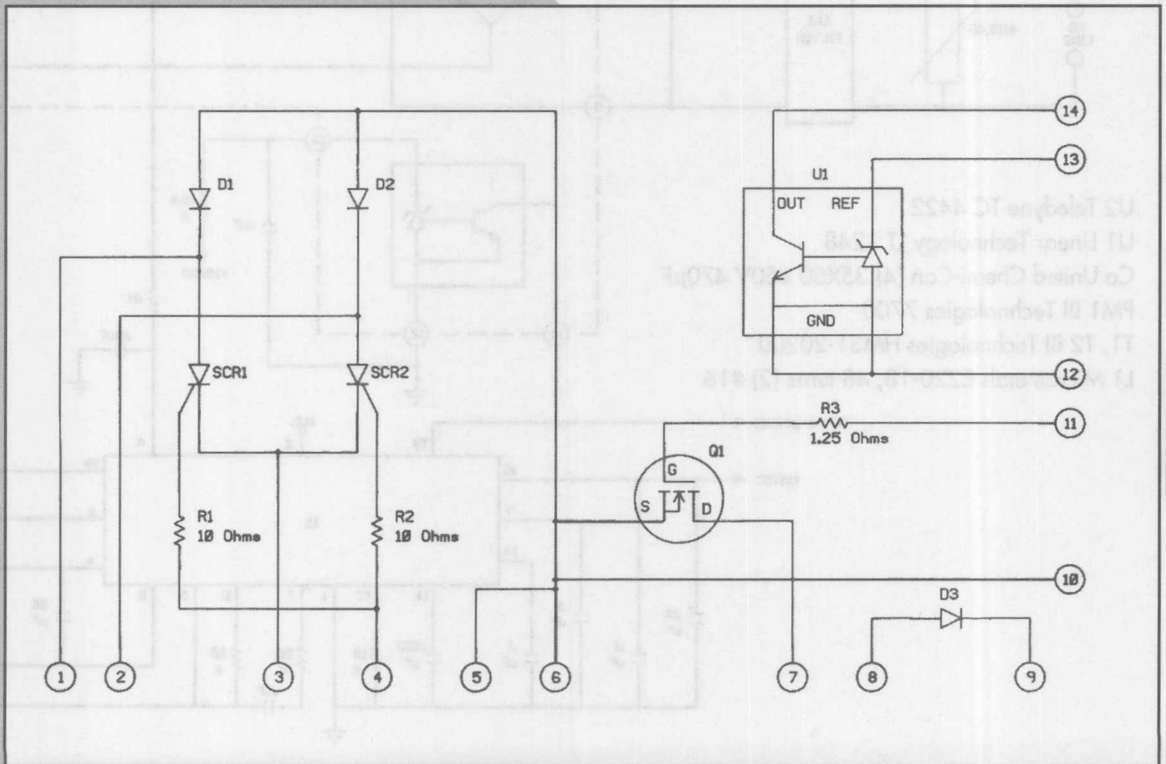


FIGURE 6: Schematic of BI model 7700 PFC module

Figure 7 shows a schematic for the 3000 watt design.

CONCLUSIONS

Power factor correction will reduce the harmonic currents in the supply system and reducing these currents will benefit the utility companies and other equipment users on the supply system. The reduction in noise and cleaner sine wave will create a more ideal power distribution system.

Active high frequency PFC will continue to grow in popularity due to its ideal sine wave input current. Power supply manufactures who incorporate power factor correction will dominate the European market as more communities require compliance to the latest legislation.

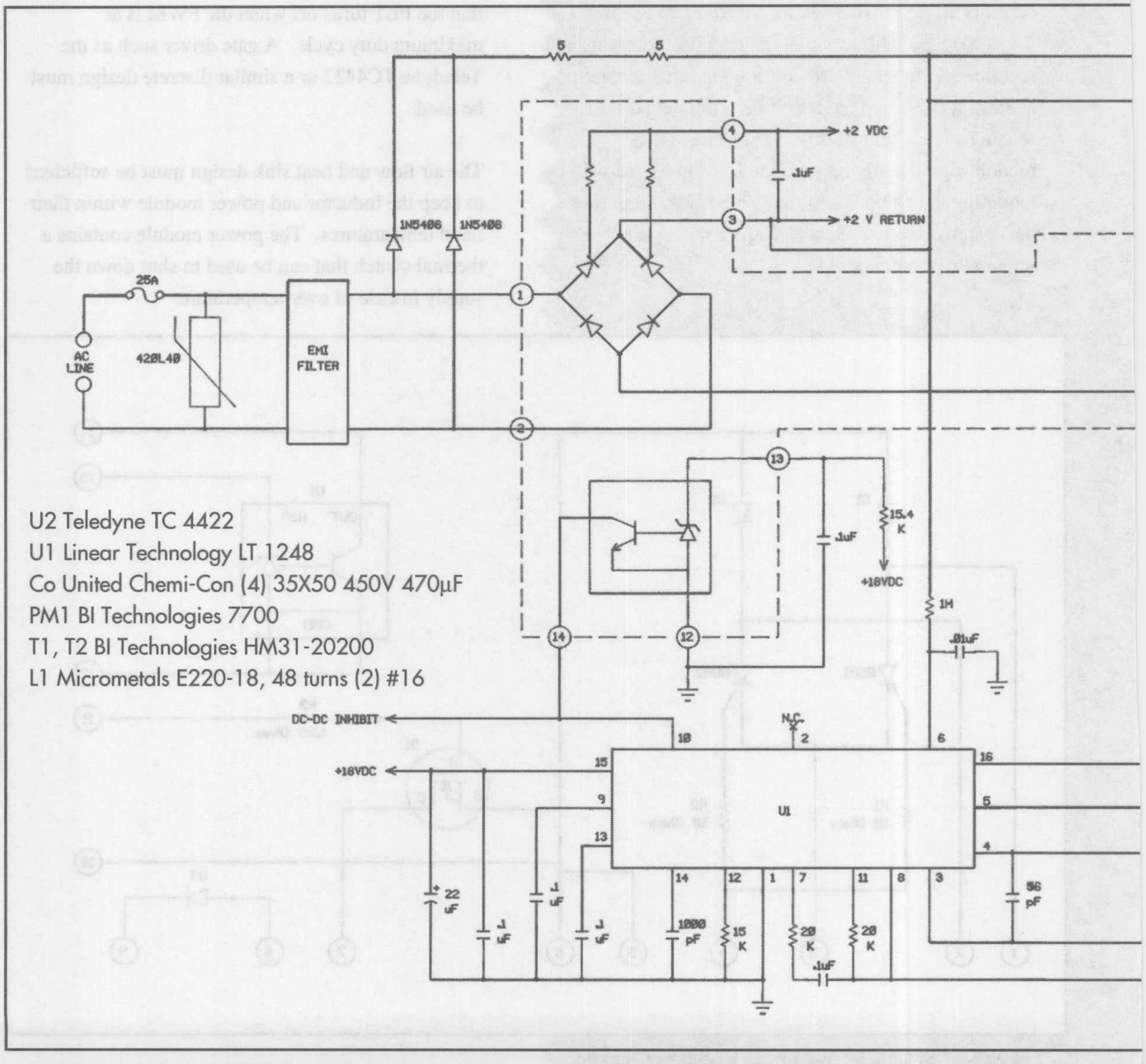
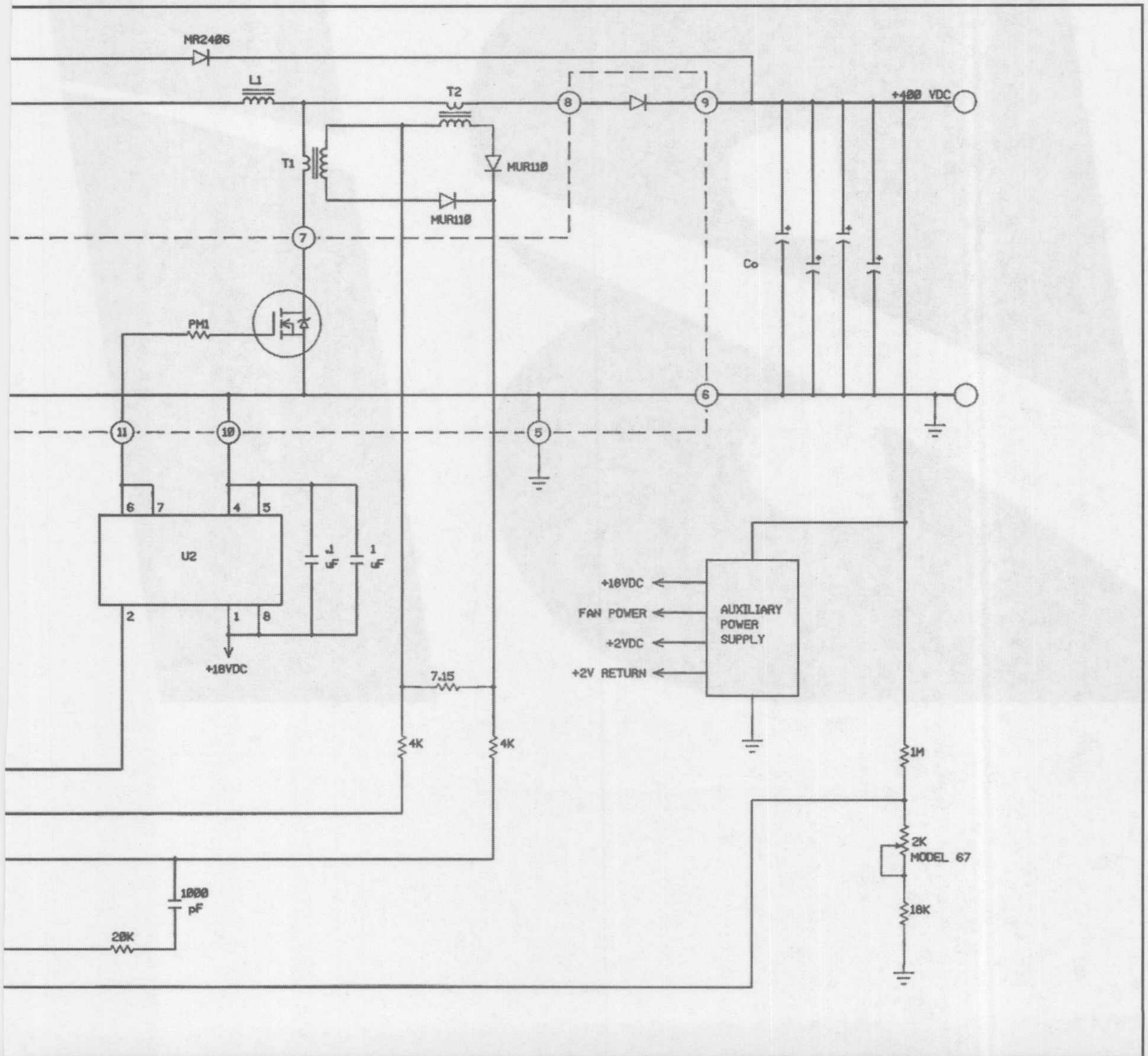


FIGURE 7: 3000 watt PFC front end


MR2406
L1
T2
T1
8
9
+400 VDC
MUR110
MUR110
7
Co
PM1
6
11
10
5
6
7
4
5
U2
1 uF
1 uF
2
1
8
+18VDC
+18VDC
FAN POWER
+2VDC
+2V RETURN
AUXILIARY
POWER
SUPPLY
7.15
4K
4K
1M
2K
MODEL 67
18K
1000
pF
20K

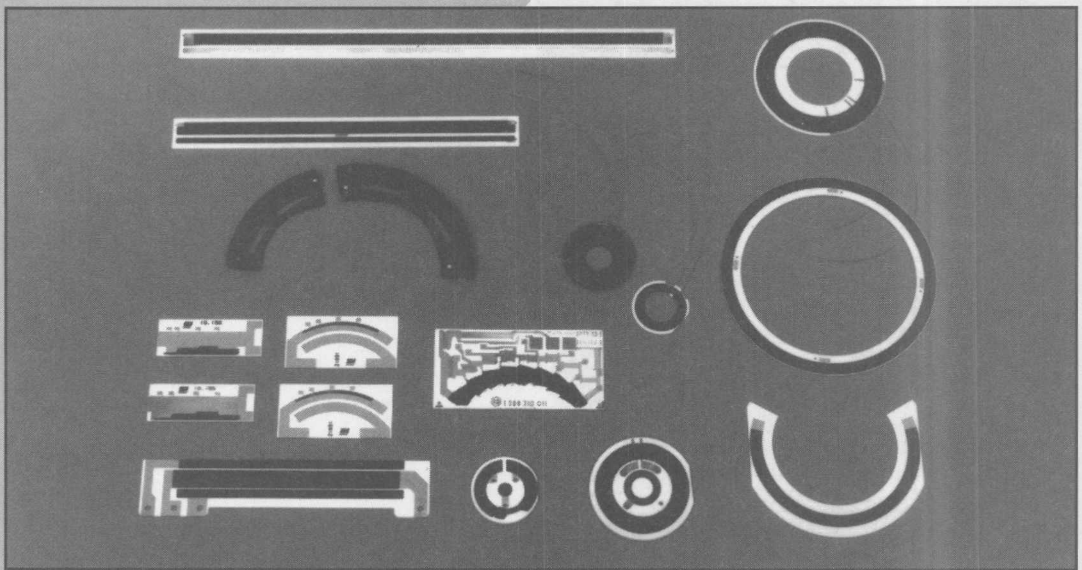
Screened Substrates

8

SCREENED SUBSTRATES

SPECIAL POTENTIOMETER ELEMENTS

BI Technologies has developed a portfolio of resistor element technologies to meet customer requirements. These include the application of high temperature ceramics and highly stable conductive plastic materials to produce elements of exceptional quality and precision.



The following is a summary of the element technologies that can be used in various potentiometer applications.

SUBSTRATE MATERIALS

Substrates can be manufactured from either high quality thermoset plastics or from electronic quality ceramics.

THERMOSET PLASTIC SUBSTRATES

- May be molded to produce a complete finished part with excellent dimensional accuracy and a high quality surface finish.
- Are typically used when the application requires a thick substrate or when indentations or recesses are deep.
- May be used to produce through holes or blind holes.
- May be used to produce transverse holes.
- Will accommodate supplemental machining operations.
- Will accommodate either insert molded or subsequently attached terminals.

CERAMIC SUBSTRATES

- Will permit high service or operating temperatures.
- Exhibit high thermal conductivity.
- May be pressed and fired to shape or may be laser machined to shape from prefired alumina sheets.

Pressed and fired substrates have the following qualities:

- Produce a part of good dimensional and surface quality.
- Accommodate supplemental laser machining.
- Can be fired with features above or below the substrate surface.
- Accommodate the creation of accurate through holes and blind holes.
- Accommodate the creation of holes with internal features.

Laser machined substrates have the following qualities:

- Accommodate the creation of irregularly shaped substrates.
- Holes may be located and drilled with high accuracy.
- Internal cutouts can be achieved.

RESISTIVE AND CONDUCTIVE FILM MATERIALS

The resistive and conductive films applied to the substrate may be either conductive plastic or cermet materials. The following discussion highlights some of the features and advantages of these two classes of materials.

CONDUCTIVE PLASTIC FILM MATERIALS

- Highly versatile and may be used on either plastic or ceramic substrates.
- Excellent for long potentiometer life due to a smooth surface.
- Can be used to obtain a wide range of resistances.
- Good choice when low cost is important.

CERMET FILM MATERIALS

- Will withstand high service temperatures.
- Exhibit good stability in high power dissipation applications.
- Can be used to obtain a wide range of resistances.

SCREEN PRINTING AND ADJUSTING THE ELEMENT

The application of the film materials to the substrate is accomplished by a precision Screen Printing process. After printing, the element may be trimmed to meet customer requirements for precise value, best linearity, or other special characteristics. Some of the special functions that BI Technologies can produce by means of precision Screen Printing and Trimming are:

- Linear and Continuous Non-linear functions.
- Two or more Sloped functions.
- Stepped functions.
- Sine, Cosine, and Special Logarithmic functions.
- Multiple Tracks.
- Special Taps for Voltage or Current.
- Multiple film Screening.
- Optimum Linearity.
- Accurate Resistance value.

OTHER STEPS IN ELEMENT FABRICATION MAY INCLUDE:

- Shaping of the substrate to meet mechanical requirements.
- Attachment of special terminals.

BI Technologies has over 30 years of experience in providing solutions to tough customer problems. Please don't hesitate to call our applications engineering group for assistance in developing a special substrate to meet your requirements.

Appendices

Appendix A
Packaging for Automation

Appendix B
AlphaNumeric Listing

Appendix C
Global Sales Offices

Global Representative Listing

Global Distributor Listing

PACKAGING FOR AUTOMATION

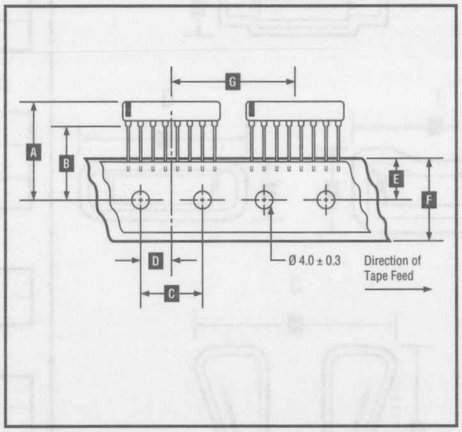
RESISTOR NETWORKS AND CHIPS

			TAPE & REEL			AMMO PACK		
Model	Description	Tape Material	Capacity	Reel Diameter (Inches)	How to Order Part # Example	Capacity	LxWxH (Inches)	How to Order Part # Example
ECONOMICAL THICK FILM / THROUGH-HOLE								
L-Series	Low Profile SIP	Paper				1,000	13 x 2.17 x 9.45	L10-1S103AP[1]
ECONOMICAL THICK FILM / SURFACE MOUNT								
BCN-2D	Chip Network	Paper	5,000	7	BCN2D103JT			
BCN-4D	Chip Network	Plastic	4,000	7	BCN4D103JE			
BCN16 4A	Chip Network	Paper	5,000	7	BCN16 4A103JT			
BCR1/16	0603 Chip Resistor	Paper	5,000	7	BCR1/16103JT			
BCR1/10	0805 Chip Resistor	Paper	5,000	7	BCR1/10103JT			
BCR1/8	1206 Chip Resistor	Paper	5,000	7	BCR1/18103JT			
BCR1/4	1210 Chip Resistor	Plastic	4,000	7	BCR1/4103JE			
BCR1/2	2010 Chip	Plastic	4,000	7	BCR1/2103JE			
BCR1	2512 Chip Resistor	Plastic	4,000	7	BCR1103JE			
BCT	0805 Chip Resistor	Plastic	4,000	7	BCT201001BE			
627	14 Pin .220" DIP	Plastic	2,000	14	627A103TR4			
628	16 Pin .220" DIP	Plastic	2,000	14	628A103TR4			
PRECISION THIN FILM / SURFACE MOUNT								
664	8 Pin .150" DIP	Plastic	1,000	7	664-A-1001FTR			
667	14 Pin .150" DIP	Plastic	1,000	7	667-A-1001FTR			
668	16 Pin .150" DIP	Plastic	800	7	668-A-1001FTR			
688	16 Pin .300" DIP	Plastic	500	7	688-A-1001FTR			

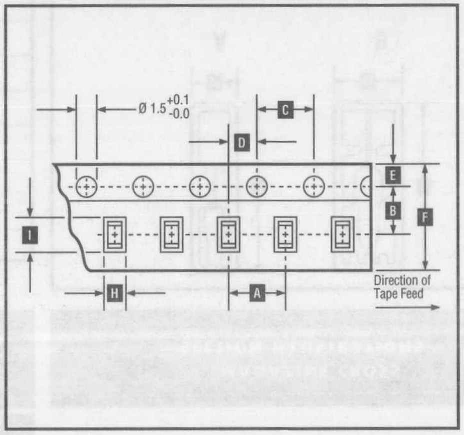
Dimensions: mm	A	B	C	D	E	F	G	H	I
L-Series[1]	21	16	12.7	6.35	9	18	25.4[2]		
BCN-2D	4	3.5	4	2	1.75	8	1.1	1.8	1.8
BCN-4D	4	5.5	4	2	1.75	12	1.1	3.5	5.6
BCN 164A	4	3.5	4	2	1.75	8	.06	2.0	3.5
BCR1/16	4	3.5	4	2	1.75	8	1	1.1	1.9
BCR1/10	4	3.5	4	2	1.75	8	1	1.65	2.4
BCR1/8	4	3.5	4	2	1.75	8	1	2.0	3.6
BCR1/4	4	3.5	4	2	1.75	8	1	2.8	3.5
BCR1/2	4	5.5	4	2	1.75	12	1	2.8	5.3
BCR1	4	5.5	4	2	1.75	12	1.1	3.6	6.9
BCT	4	3.5	4	2	1.75	8	2.5	1.25	2.0
627/628[4]	12	11.5	4	2	1.75	24	6.5	8.13	10.21[3]
664[4]	8	5.5	4	2	1.75	12	6.5	6.40	5.25
667[4]	8	7.5	4	2	1.75	16	8.0	6.40	9.00
668[4]	8	7.5	4	2	1.75	16	8.0	6.40	10.25
688[4]	12	11.5	4	2	1.75	24	12	10.50	10.75

[1] For Ammo Pack option - Model must be ordered with steel pins.
[2] L-Series with greater than 8 pins dimension 'G' = 38.1
[3] Model 628 dimension 'I' = 11.48
[4] Pin #1 positioned at sprocket hole side

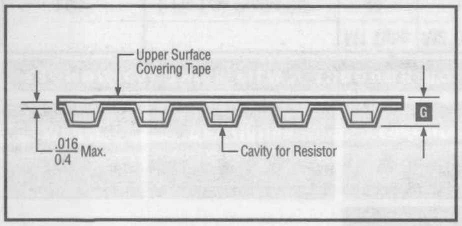
L-SERIES AMMO PACK



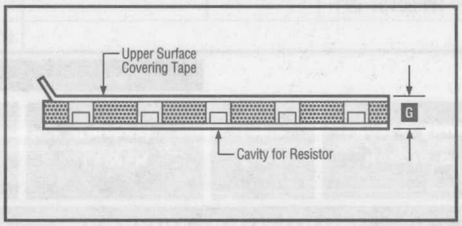
PAPER & PLASTIC TAPE (TOP VIEW)



PLASTIC TAPE (SIDE VIEW)



PAPER TAPE (SIDE VIEW)



Packaging per EIA RS-468 radial lead and EIA-481 surface mount configuration.

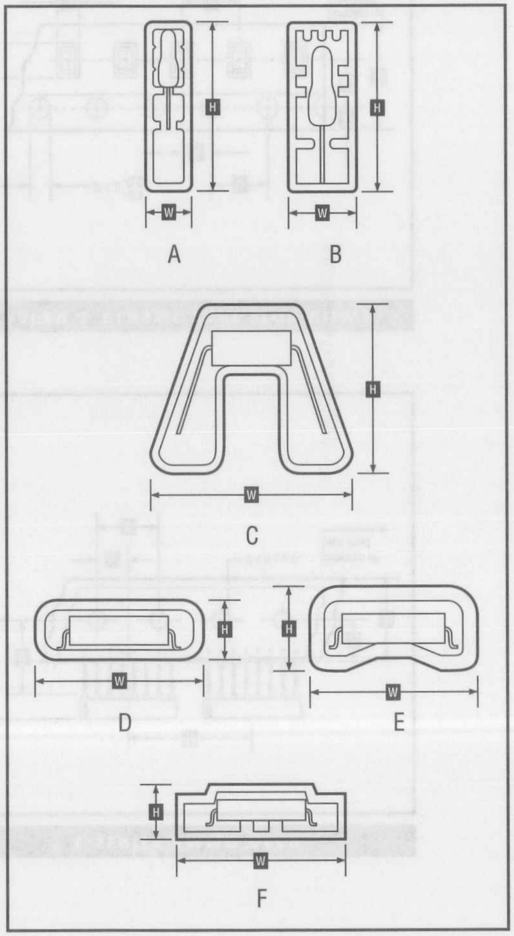
Bi technologies CORPORATION

PACKAGING FOR AUTOMATION

RESISTOR NETWORKS

Model	Description	Capacity (MAGAZINE (ANTI-STATIC))		LxWxH (Inches)	Tube Style	How to Order Part # Example
ECONOMICAL THICK FILM / THROUGH-HOLE						
		M1 Tube	M2 Tube			
L05	5 Pin Low Profile SIP	40	38	M1=22.8 x .15 x .52 M2=20 x .20 x .43	A (M1) B (M2)	L05-1C103-M1 or M2
L06	6 Pin Low Profile SIP	34	32			L06-1C103-M1 or M2
L07	7 Pin Low Profile SIP	29	27			L07-1C103-M1 or M2
L08	8 Pin Low Profile SIP	25	23			L08-1C103-M1 or M2
L09	9 Pin Low Profile SIP	23	21			L09-1C103-M1 or M2
L10	10 Pin Low Profile SIP	20	19			L10-1C103-M1 or M2
L11	11 Pin Low Profile SIP	19	17			L11-1C103-M1 or M2
887	20 Pin DIP	20		22.25 x .6 x .483	C	887-1-R10K
888	18 Pin DIP	20		19.75 x .6 x .483	C	888-1-R10K
898	16 Pin DIP	25		22.25 x .6 x .483	C	898-1-R10K
899	14 Pin DIP	25		19.75 x .6 x .483	C	899-1-R10K
ECONOMICAL THICK FILM / SURFACE MOUNT						
627	14 Pin .220" DIP	50		20.5 x .425 x .15	D	627-B-103
628	16 Pin .220" DIP	50		23 x .425 x .15	D	628-B-103
PRECISION THIN FILM / THROUGH-HOLE						
694	8 Pin DIP	50		21 x .6 x .49	C	694-1-R10KF
698	16 Pin DIP	25		21 x .6 x .49	C	698-1-R10KF
699	14 Pin DIP	25		21 x .6 x .49	C	699-1-R10KF
PRECISION THIN FILM / SURFACE MOUNT						
654	8 Pin RF Attenuator	100		20.5 x .310 x .150	E	654 2dB
664	8 Pin .150" DIP	100		20.5 x .310 x .150	E	664-B-1002F
667	14 Pin .150" DIP	50		18.0 x .310 x .150	E	667-B-1002F
668	16 Pin .150" DIP	50		20.0 x .310 x .150	E	668-B-1002F
688	16 Pin .300" DIP	50		21.5 x .580 x .185	F	688-B-1003F

MAGAZINE CROSS SECTION ILLUSTRATIONS



BI technologies CORPORATION

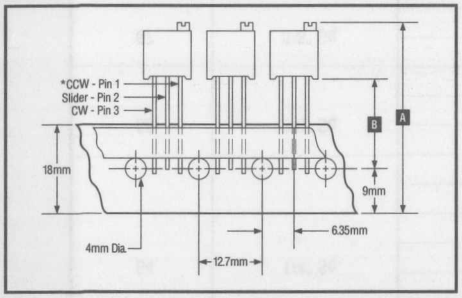
PACKAGING FOR AUTOMATION

TRIMMING POTENTIOMETERS

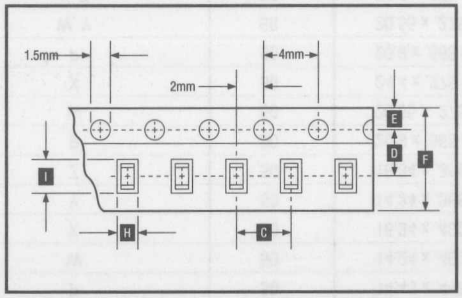
Model	Size	Tape Material	Available Pin Styles	Capacity	TAPE & REEL: Reel Diameter (Inches)	TAPE & REEL: How to Order Part # Example	AMMO PACK: Box LxWxH (Inches)	AMMO PACK: How to Order Part # Example
SINGLE TURN / THROUGH-HOLE								
24	4mm Dia.	Paper	U	1,000	14	24UR10KTR		
25	1/4" Sq.	Paper	U, V	1,000	14	25UR10KTR	13.39 x 2 x 13.78	25UR10KAP
72	3/8" Sq.	Paper	RW	1,000	14	72RWFR10KTR	13 x 1.8 x 10	72RWFR10KAP
82	1/4" Dia.	Paper	W	1,000	14	82WFR10KTR	13 x 1.8 x 10	82WFR10KAP
MULTI-TURN / THROUGH-HOLE								
64	1/4" Sq.	Paper	Y, Z	1,000	14	64YFR10KTR	13 x 1.8 x 10	64YFR10KAP
66	3/8" Sq.	Paper	W, X	1,000	14	66WFR10KTR	13 x 1.8 x 10	66WFR10KAP
67	3/8" Sq.	Paper	W, X	1,000	14	67WFR10KTR	13 x 1.8 x 10	67WFR10KAP
68	3/8" Sq.	Paper	W, X	1,000	14	68WFR10KTR	13 x 1.8 x 10	68WFR10KAP
SINGLE TURN / SURFACE MOUNT								
21	4mm Chip	Plastic	W, X, Z	750	7	21WR10KTR		
22	3mm Chip	Plastic	A, B	1,000	7	22AR10KTR		
23	4mm Sq.	Plastic	A, B, S	A, B=500 S=750	7	23AR10KTR		
83	1/4" Sq.	Plastic	P	1,000	13	83PR10KTR		
MULTI-TURN / SURFACE MOUNT								
84	1/4" Sq.	Plastic	P	1,000	14	84PR10KTR		
44	4mm	Plastic	W,G,J	1,000	13	44 WR10KTR		

Radial lead packaging per EIA-RS-468 and surface mount per EIA-481

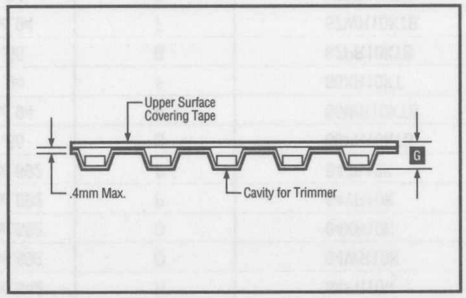
PAPER TAPE (SIDE VIEW)



PLASTIC TAPE (SIDE VIEW)



PLASTIC TAPE (SIDE VIEW)



Direction of Feed ⟶ Pin #1 is initial pin out for both paper and plastic tape except models 24, 25, and 72 where pins 1 and 3 are reversed.

	Dimensions: mm	
MODEL	A	B
24	22.7	18
25	30	20
64	37.09	18.03
66/67/68	41.66	18.03
72	41.66	18.03
82	35.56	18.03

	Dimensions: mm						
MODEL	C	D	E	F	G	H	I
21	8	5.63	1.5	12	2.4	4.5	4.9
22	8	5.5	1.75	12	2.6	3.8	5.2
23A,B	8	5.5	1.75	12	3.2	5.4	7.2
23S	8	5.5	1.75	12	6.4	5.2	7
83	12	7.5	1.75	16	5.61	7.11	7.11
84W	16	11.5	1.75	24	8.89	13.2	14.8
84X	16	11.5	1.75	24	8.13	13.2	14.8
44W	12	7.5	1.75	16	5.46	7.36	7.87
44G,J	12	7.5	1.75	16	4.83	7.87	7.87

Metrix conversions
1 Inch = 25.4mm

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PACKAGING FOR AUTOMATION

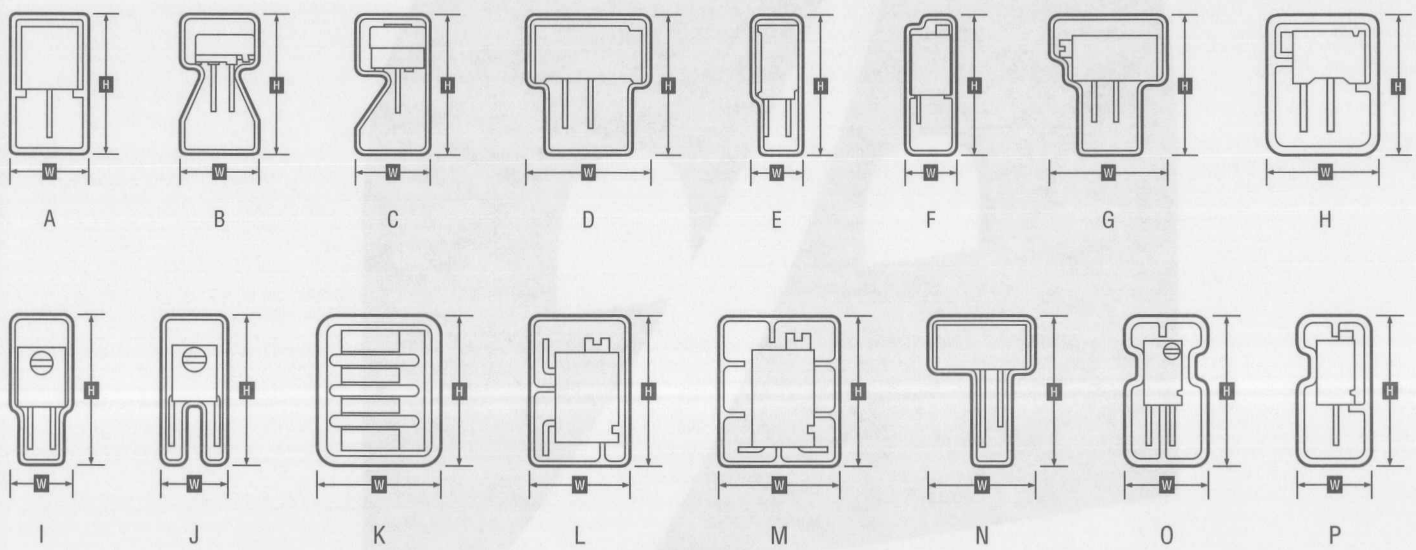
TRIMMING POTENTIOMETERS

Model	Size	Available Pin Styles	MAGAZINE (ANTI-STATIC) Capacity	LxWxH (Inches)	Tube Style	How to Order Part # Example
SINGLE TURN / THROUGH-HOLE						
25	1/4" Sq.	U	70	19.7 x .33 x .59	A	25UR10KTB
		V	70	19.7 x .33 x .71	A	25VR10KTB
62	1/4" Dia.	M	100	27.18 x .344 x .645	C	62MR10KTB
		P	100	26.88 x .344 x .645	B	62PR10KTB
72	3/8" Sq.	P, PM	50	19.89 x .485 x .555	D	72PR10KTB
		RX, RXL ,RXW, X, XL, XW, RW	50	19.69 x .295 x .765	E	72XR10KTB
82	1/4" Dia.	M	100	26.88 x .344 x .585	C	82MR10KTB
		P	100	26.88 x .344 x .585	B	82PR10KTB
		PA	50	15.55 x .275 x .94	F	82PAR10KTB
		W	100	26.88 x .344 x .645	C	82WR10KTB
93	1/2" Dia.	P	50	26.08 x .585 x .84	N	93PR10KTB
MULTI-TURN / THROUGH-HOLE						
64	1/4" Sq.	P	50	14.43 x .446 x .542	H	64PR10K
		W	50	14.24 x .402 x .692	O	64WR10K
		X	50	16.34 x .402 x .692	O	64XR10K
		Y	50	14.24 x .356 x .692	P	64YR10K
		Z	50	16.34 x .356 x .692	P	64ZR10K
66	3/8" Sq.	P	50	20.9 x .565 x .66	G	66PR10KTB
		W	50	20.55 x .275 x .94	F	66WR10KTB
		X	50	24.4 x .275 x .94	F	66XR10KT
67	3/8" Sq.	P	50	20.9 x .565 x .66	G	67PR10KTB
		W, Y	50	20.55 x .275 x .94	F	67WR10KTB
		X, Z	50	24.4 x .275 x .94	F	67XR10KTB
68	3/8" Sq.	P	50	20.9 x .565 x .66	G	68PR10KTB
		W	100	20.4 x .325 x .905	F	68WR10KTB
		X	50	24.15 x .325 x .905	F	68XR10KTB
89	3/4" Rect.	P, PH, X, XH	25	21.16 x .28 x .655	I	89PR10KTB
		W, WH	25	21.16 x .28 x .66	J	89WR10KTB

Model	Size	Available Pin Styles	MAGAZINE (ANTI-STATIC) Capacity	LxWxH (Inches)	Tube Style	How to Order Part # Example
SINGLE TURN / SURFACE MOUNT						
83	1/4" Sq.	Y	50	19.05 x .30 x .35	K	83YR10KTB
MULTI-TURN / SURFACE MOUNT						
84	1/4" Sq.	P	50	14.55 x .32 x .472	L	84PR10K
		W	50	14.55 x .377 x .472	M	84WR10K
		X	50	16.6 x .377 x .472	M	84XR10K

All units oriented with pin #1 to the same side.

MAGAZINE CROSS SECTION ILLUSTRATIONS



BI technologies CORPORATION

MODEL #	DESCRIPTION	SECTION-PAGE
A	Precision Potentiometer	2-5
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BCN Series	Chip Resistor Network	4-5
BCN 2D	Chip Resistor Network	4-5
BCN 4D	Chip Resistor Network	4-5
BCN 16	Chip Resistor Network	4-5
BCN 31	Chip Resistor Network	4-5
BCR Series	Chip Resistor	5-3
BCR 1	Chip Resistor	5-3
BCR 1/2	Chip Resistor	5-3
BCR 1/4	Chip Resistor	5-3
BCR 1/8	Chip Resistor	5-3
BCR 1/10	Chip Resistor	5-3
BCR 1/16	Chip Resistor	5-3
BCR 1/32	Chip Resistor	5-3
BCT Series	Chip Resistor	5-7
BCT 20	Chip Resistor	5-7
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BH5	Resistor Network	4-11
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BH9	Resistor Network	4-11
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BMB	Chip Bead	6-7
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C	Precision Potentiometer	2-13
C Series	Capacitor Network	4-19
C4	Capacitor Network	4-19
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C10	Capacitor Network	4-19
C11	Capacitor Network	4-19
C12	Capacitor Network	4-19
C13	Capacitor Network	4-19
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CR Series	Resistor/Capacitor Network	4-21
CR4	Resistor/Capacitor Network	4-21
CR5	Resistor/Capacitor Network	4-21
CR6	Resistor/Capacitor Network	4-21
CR7	Resistor/Capacitor Network	4-21
CR8	Resistor/Capacitor Network	4-21
CR9	Resistor/Capacitor Network	4-21
CR10	Resistor/Capacitor Network	4-21
CR11	Resistor/Capacitor Network	4-21
CR12	Resistor/Capacitor Network	4-21
CR13	Resistor/Capacitor Network	4-21
CR14	Resistor/Capacitor Network	4-21
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D5	Diode Network	4-25
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MODEL #	DESCRIPTION	SECTION-PAGE
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D8	Diode Network	4-25
D9	Diode Network	4-25
D10	Diode Network	4-25
D11	Diode Network	4-25
D12	Diode Network	4-25
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HM15	Magnetic Component	6-21
HM18	Magnetic Component	6-23
HM19	Magnetic Component	6-27
HM28	Magnetic Component	6-29
HM31	Magnetic Component	6-35
HM32	Magnetic Component	6-39
HM33	Magnetic Component	6-41
HM41	Magnetic Component	6-43
HM50	Magnetic Component	6-45
HM51	Magnetic Component	6-45
HM77	Magnetic Component	6-49
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L Series	Resistor Network	4-27
L04	Resistor Network	4-27
L05	Resistor Network	4-27
L06	Resistor Network	4-27
L07	Resistor Network	4-27
L08	Resistor Network	4-27
L09	Resistor Network	4-27
L10	Resistor Network	4-27
L11	Resistor Network	4-27
L12	Resistor Network	4-27
L13	Resistor Network	4-27

MODEL #	DESCRIPTION	SECTION-PAGE
L14	Resistor Network	4-27
M Series	Resistor Network	4-33
M4	Resistor Network	4-33
M5	Resistor Network	4-33
M6	Resistor Network	4-33
M7	Resistor Network	4-33
M8	Resistor Network	4-33
M9	Resistor Network	4-33
M10	Resistor Network	4-33
M11	Resistor Network	4-33
M12	Resistor Network	4-33
M13	Resistor Network	4-33
M14	Resistor Network	4-33
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NQS16	Resistor Network	4-37
NQS20	Resistor Network	4-37
NQS24	Resistor Network	4-37
RB	Turns Counting Dial	3-12
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RBC	Turns Counting Dial	3-12
RBD	Turns Counting Dial	3-12
RBJ	Turns Counting Dial	3-12
RC Series	Resistor/Capacitor Chip Network	4-41
RC3	Resistor/Capacitor Chip Network	4-41
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T Series	Resistor Network	4-45
T4	Resistor Network	4-45
T5	Resistor Network	4-45
T6	Resistor Network	4-45
T7	Resistor Network	4-45
T8	Resistor Network	4-45
T9	Resistor Network	4-45
T10	Resistor Network	4-45
T11	Resistor Network	4-45
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MODEL #	DESCRIPTION	SECTION-PAGE
T13	Resistor Network	4-45
T14	Resistor Network	4-45
21W	Chip Trimming Potentiometer	1-11
21X	Chip Trimming Potentiometer	1-11
21Z	Chip Trimming Potentiometer	1-11
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23C	Trimming Potentiometer	1-19
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23GL	Trimming Potentiometer	1-23
23J	Trimming Potentiometer	1-23
23S	Trimming Potentiometer	1-19
24S	Trimming Potentiometer	1-27
24U	Trimming Potentiometer	1-27
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25S	Trimming Potentiometer	1-31
25U	Trimming Potentiometer	1-31
25V	Trimming Potentiometer	1-31
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MODEL #	DESCRIPTION	SECTION-PAGE
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89P	Trimming Potentiometer	1-79
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89W	Trimming Potentiometer	1-79
89WH	Trimming Potentiometer	1-79
89X	Trimming Potentiometer	1-79
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91A	Trimming Potentiometer	1-85
91B	Trimming Potentiometer	1-85
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91E	Trimming Potentiometer	1-85
91T	Trimming Potentiometer	1-85
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